THE
WORLD'S COMMERCIAL PRODUCTS

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A DESCRIPTIVE ACCOUNT OF THE ECONOMIC PLANTS
OF THE WORLD AND OF THEIR COMMERCIAL USES

By

W. G. FREEMAN, B.Sc., F.L.S.
Superintendent, Colonial Economic Collections, Imperial Institute, London.

and

S. E. CHANDLER, D.Sc., F.L.S.
Assistant, Colonial Economic Collections, Imperial Institute, London.

WITH CONTRIBUTIONS BY

T. A. HENRY, D.Sc., F.C.S., C. E. JONES, B.Sc., F.L.S.
and E. H. WILSON.

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PREFACE

ALTHOUGH the products of the plant world are of enormous commercial importance and enter largely into the every-day life of all of us, nevertheless it has hitherto been impossible to obtain an inexpensive illustrated book, written in English, affording a general summary of information concerning the useful plants of the world and their commercial utilisation. Works dealing with special groups are available, and innumerable papers on plant products are to be found in the publications of our economic and scientific departments at home and in the Colonies. This literature, however, is not readily available to a very large number of enquirers who desire a comparatively brief account of perhaps several important products. Illustrations of many economic plants, and of the methods employed in their cultivation and in the preparation of their produce, are even more inaccessible.

The WORLD'S COMMERCIAL PRODUCTS presents this information in English for the first time, accompanied by a wealth of illustrations many of which are entirely new. Every effort has been made to keep the book free from technicalities, and the plants are, as far as possible, referred to by their common names, although the scientific names are usually given as well, since they are often indispensable in determining exactly the plants referred to. The coloured plates will often be of assistance in depicting scenes to which full justice cannot be done in "black and white," but all the illustrations are from photographs, and can be depended upon as portraying faithfully the scenes they represent. Maps have been added showing the distribution of the principal cultivated plants, and many useful lessons may be drawn from them.

One of the authors has spent some six years in the tropics, in Ceylon, the West Indies, and West Africa, engaged in economic botanical work, and much of the matter is described from first-hand knowledge. In addition, the copious literature referred to below has been freely drawn upon, and special acknowledgments are due to the publications of the Royal Botanic Gardens, Kew, the Bulletin of the Imperial Institute, the publications of the Imperial Department of Agriculture for the West Indies, the Agricultural Journal of the Royal Botanic Garden, Ceylon, Sir George Watt's "Dictionary of the Economic Products of India," Spon's "Encyclopædia of Arts and Manufactures," Lewkowitsch's "Oils and Fats," Greenish's "Materia Medica," Wright's "Para Rubber," the International Sugar Journal, Noel Deer's "Sugar Cane," Willis's "Dictionary of the Flowering Plants and Ferns,"

Engler and Prantl's "Die Natürlichen Pflanzenfamilien" and last, but far from least, the publications of the United States of America Department of Agriculture.

Great advantage has accrued from the co-operation of other workers. Dr. T. A. Henry, F.C.S., has contributed the sections on Gums, Resins, Dyes, Tans, and Essential Oils, Mr. C. E. Jones, B.Sc., F.L.S., the section on Oils and Fats, and Mr. E. H. Wilson the sections on Fruits and Vegetables. The Timber article has had the benefit of Mr. J. H. Badcock's extensive practical knowledge of this subject.

Limitations of space have prevented every plant product being included, but care has been taken to deal with the more important, and it is hoped that the specialist and the general reader alike will find the WORLD'S COMMERCIAL PRODUCTS a useful possession.

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ERRATA

p. **66**, in legend of illustration, for "YOUNG CULTIVATION" read "YOUNG PLANTATION"

p. **74**, in legend of illustration, for "BORASSUS PALMS" read "OIL PALMS"

p. **116**, in legend of illustration, for "CEYLON—THE FELLING OF THE FRUIT" read "CEYLON—BREAKING THE PODS"

p. **282**, line seven from *top* of page, for "In 1896 Ceylon" read "In 1876 Ceylon"

p. **282**, line twenty-three from *bottom* of page, for "1897-8 young plants" read "1877-8 young plants"

p. **309**, lines six and five from *bottom* of page, for "REDWOOD (*Sequoia sempervirens*)" read "REDWOOD (*Sequoia sempervirens*)"

p. **310**, line three from *top* of page, for (*Sequoia Washingtoniana*) read (*Sequoia Washingtoniana*)

p. **321**, coloured plate, facing, for "COTTON FLOWER AND BALL" read "COTTON FLOWER AND BOLL"

p. **321**, in legend of illustration, for "COCO-NUT YUCCA" read "COCO-NUT PALMS AND YUCCA"

p. **325**, in legend of illustration, for "BORASSUS PALMS" read "SCREW PINES (Pandanus) with Borassus Palm on the left."

p. **335**, in legend of illustration, for "DRYING QUININE" read "FOUNDING A QUININE PLANTATION"

p. **336**, in legend of illustration, for "FOUNDING A QUININE PLANTATION" read "DRYING QUININE"

p. **344**, in acknowledgment of illustration, for "*Photo by T. G. Hall, Esq., F.L.S.*" read "*Photo by T. G. Hill, Esq., F.L.S.*"



From a photograph by N. P. Edwards, Littlehampton

Coloured by Miss Seth

THRESHING WHEAT ON A CANADIAN PRAIRIE



By permission of the "Canada" Newspaper

BREAKING NEW GROUND

INTRODUCTION

THE vegetable products of the world are of great interest to man, as upon them he is dependent for his very existence, his clothing, his home, his means of locomotion, and many of his pleasures. Imagine for a moment what the world would be, if it was deprived of plant life. Wheat, rice, millets, oats, maize, and the other cereals, on one or other of which every individual of both the most primitive and the most civilized nations depends for his sustenance, would disappear, together with potatoes, yams, cassava or manioc, and all the important starch-producing plants. There would be no fruits or vegetables; tea, coffee, cocoa, and sugar would vanish; tobacco and many of the chief drugs would cease to be obtainable. Most modern sports would be impracticable because there would be no india-rubber for balls and tyres, no wood for bats, golf sticks, and racquets, and leather could no longer be tanned. Cotton and linen would go, and wool, hair, and silk would be the only fibres for the manufacture of cloths and other textiles. There would be no wines or spirits, in fact, life as we know it at present would come to a standstill. Supposing, however, that man could exist in a world containing no plants, to what extent could he manufacture, with all the assistance which modern science affords him, the substances necessary for his life? In spite of the enormous strides which science, and particularly chemical science, has made, man could not support himself. It is true that one section of the commercial world has recently been profoundly affected by the artificial manufacture of indigo. Another section is seriously considering the situation created by chemists having discovered how to make vanillin, the essential principle of the vanilla "bean." The development of the coal-tar industry has practically extinguished certain planting industries. From time to time fears are expressed that the artificial manufacture of sugar, already possible, or that the preparation of chemical rubber may become commercially practicable. In spite, however, of these developments the fact remains that man is unable to repeat the processes by which the wheat plant manufactures starch from water and the atmosphere. He cannot from similar elementary substances make cotton, wood, the active principles of tea, coffee, cocoa, or tobacco, for all of which he is dependent on plant life. There is no need to elaborate the matter; enough has been said to prove the absolute importance and necessity to man of the vegetable products of the world.

There is a tendency, however, for man as he becomes more civilised to fail to recognise



HARVESTING PADDY IN CEYLON

the degree to which he is dependent on the herbs of the field for his support. The dweller in cities is accustomed to find everything provided for him in a finished condition, and he accepts it without realising whence it came or how it was procured. This is easily seen in the case of a child spending his early years in a town. It comes to him as a revelation that his daily bread has any connection with the corn he has perhaps seen in a field during a holiday, that sugar and his favourite sweetstuffs are derived from the sugar cane grown in the tropics, or from the more familiar beet-root, that his rubber ball is the produce of a forest tree, and that his clothes, at any rate in part, have also been gathered in the field. To the country child things are different. He lives in touch with Nature, and the seasons for sowing and harvesting are important events in his daily life. Still more so is this the case with primitive people. The native races of the East and the West Indies, Africa, and elsewhere are directly dependent on the soil for their livelihood. A bad season makes itself felt at once by diminishing the available food, whilst a plenteous harvest means a full table. We have only to go back a comparatively few years to find the same state of affairs the universal rule in this country, and in many parts it is still so at the present day.

Primitive man lived directly on the wild plants he found in his native country, and from these also he made his few clothes, his house, his weapons, his canoes, and the other necessaries of his simple life, supplementing the plant products from the animal and mineral worlds. At a very early stage man took the important step of growing for himself the plants he most needed, and agriculture, or the tilling of the soil, is perhaps the most ancient occupation of mankind. The natives on the West Coast of Africa afford an example of the practice of simple agriculture. A tribe settles in some locality which attracts it for one reason or another, such as accessibility of water, fertile soil, abundance of oil palms, or other important wild plants, and security from enemies. An area is cleared by cutting down and burning everything, except a few trees so large as to defy man's efforts, and others which it is desired to retain. On the land so cleared crops are raised. Indian corn, Guinea corn, cassava, yams, sweet potatoes, bananas, ground or monkey nuts, various peas and beans, and perhaps some cotton are planted, and on these, supplemented by the products of wild plants and animals from the bush, the tribe lives in comfort. Agriculture, as we understand the term, is not practised, and it is found that the soil is soon exhausted. This is of no serious consequence where there is far more land available than is required, and even to move the village or town to a new place is a task entailing no great labour, although in most cases it is sufficient to abandon one "farm" and to clear and cultivate another.

In sparsely inhabited countries millions of people live in this manner at the present day. With increasing population these methods become impossible, and in China we find the soil cultivated to its fullest extent, and all possible means adopted to increase the output from a given area.

In most countries it was soon found that all districts were not equally adapted to the cultivation of every crop, and a simple system of exchange arose by which one group bartered perhaps their surplus cotton for rice or some other commodity to the cultivation of which their own locality was not suited. In closely adjacent areas this exchange would be carried out directly by the producers. As man became more enterprising and the means of communication developed, people travelled further afield, and now in Africa men journey hundreds of miles with a portion of their crop to exchange it for some valued product brought to the rendezvous from perhaps an equal distance by another group of producers. The business of the exchange of goods had reached a high degree of development before the Christian Era. The Carthaginians

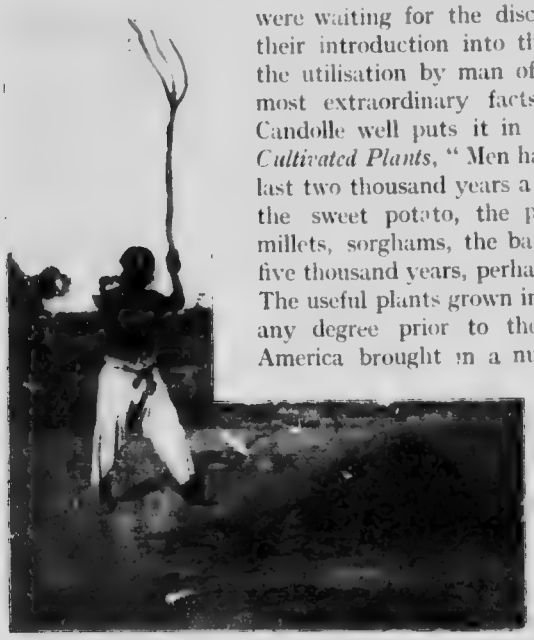


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BIG TREES

traded throughout the Mediterranean and also with Britain, the Baltic, and the Azores; by means of caravans they penetrated Africa, reaching as far as Egypt to the East, Morocco to the West, and across the Sahara to the River Niger. The Romans, the Greeks, the Venetians were all trading peoples, and by their enterprise the wealth of India became known and accessible.

Another result of this intercourse between nations was that the useful plants of the world became widely distributed. The cultivation of the most important of those of the Old World, those which are absolutely necessary to man, dates from very remote ages. If we had been preparing, some three or four thousand years ago, a book similar to the present on the commercially useful plants we should have had to include wheat, barley, rice, millets of various kinds, tea, flax, hemp, the vine, the olive, the date, bananas, various legumes, and other vegetables. It is true we should not have heard of the potato or the sweet potato, tobacco, cocoa, or Indian corn (maize), but these have been cultivated for almost as long by the American races, and were waiting for the discoveries of Columbus and his successors for their introduction into the Old World. This early discovery and the utilisation by man of the most valuable plants is one of the most extraordinary facts in the history of agriculture. As De Candolle well puts it in his most interesting book on *The Origin of Cultivated Plants*, "Men have not discovered and cultivated during the last two thousand years a single species which can rival maize, rice, the sweet potato, the potato, the bread fruit, the date, cereals, millets, sorghams, the banana, soy. These date from three, four, or five thousand years, perhaps even in some cases six thousand years." The useful plants grown in Græco-Roman times were not added to in any degree prior to the discovery of America. The finding of America brought in a number of plants new to the Old World, and of very high value, such as the potato, maize, sweet potato, tobacco, and cocoa. Within a comparatively short time these plants also found their way into other countries. The potato reached Europe at about the end of the sixteenth century, and as indicating the interest which attached to this novelty we find that in a book, Gerard's *Herbal*, published in 1597, Gerard selected, in presenting his own portrait, to hold in his hand a flowering branch of the potato plant, which he had cultivated in his garden. The maize plant rapidly reached almost all tropical countries, cocoa was taken to Ceylon and elsewhere, and in this way the greatest additions to the number of really important cultivated plants of the Old World since very early times was brought about. Another important American plant, cinchona, the source of quinine, was introduced to cultivation largely through the agency of a man still living—Sir Clements Markham, K.C.B., F.R.S. It helped Ceylon over the coffee crisis, and it is at the present time the source of an important industry in Java.



A CHINAMAN THRESHING MILLET

As man's life became more complex and his wants increased he found it necessary to form plantations of other species, such as fibre and rubber-yielding plants. Para rubber is the most important of the new industries in the East, where in Ceylon and the Malay peninsula its cultivation is attracting much labour and capital. This valuable plant is a native of Brazil, and formerly the whole of the rubber it yielded was collected from wild trees scattered



THE VINTAGE IN PORTUGAL

through the dense forests in the Amazon valley. As recently as 1886, by the enterprise of the Indian Government and with the assistance of the Royal Botanic Gardens, Kew, it was successfully introduced into Ceylon, and promises to become an important source of wealth. Cultivation of this and other rubber plants is also being undertaken in parts of the tropics, and the rubber trees are amongst the latest addition to the list of cultivated plants, an addition which has taken place in our own generation.

It is probably safe to say that by this time most of the useful plants of the world are known. We are not likely to discover anywhere a plant which will rival wheat, rice, cotton, tea, coffee, cocoa, the vine, or the chief sugar producing plants for their respective products. We may add considerably to the number of cultivated plants, when, as has happened with rubber trees, it becomes advantageous or desirable to cultivate them instead of relying on the wild product. Much work, too, remains to be done in improving the plants already to hand. This is one of the most important divisions of the work of the botanic gardens and experiment stations throughout the world, and in discussing sugar attention is directed to the good results attained on these lines with the sugar cane in the West Indies, Java, etc., and with the sugar beet in Europe. Similar work on other plants is being conducted elsewhere, and is referred to in its appropriate place. At the present time we have throughout the British Empire a well-developed system for securing the introduction of useful plants into any colony, and there are no serious difficulties in introducing any plant into any place where it is likely to thrive and its produce to obtain a profitable market. The latter depends to a great extent on facilities for transport. That these are in a high state of efficiency is easily recognised when we think of the origin of the ordinary items of our every-day fare. The flour of which our bread is made comes from America, India, Argentine, Australia, Russia, and elsewhere, tea from India, Ceylon, and China, coffee from Brazil and Central America, cocoa from Ecuador, the West Indies, West Africa, etc., sugar from the East and West Indies or Europe according as we use cane or beet. These are all products which are easily carried, and are not damaged even if delayed in the voyage. During recent years, however, other items have been added to the import list, and the Channel Islands and the South of France provide us regularly with large quantities of potatoes, vegetables, and fruit. More striking, however, are the developments resulting from scientific discoveries which have rendered possible rapid means of transport and cold storage. Our apples, a few years ago essentially a home crop, come to a very considerable extent from Canada, the United States, and Tasmania. In the latter instance they have to withstand a voyage of six weeks' duration, starting in the temperate region, passing through the tropics, and terminating in the temperate clime of another hemisphere. Yet these apples, unpacked, look as good as when they were picked. Bananas, which are increasing in popularity, come from such widely separated places as the Canary Islands, Jamaica, Costa Rica, and Barbados. Delicate fruits, such as grapes, reach us in safety, and peaches and plums from the Cape of Good Hope can be seen in increasing numbers in British markets. Fruits are so easily damaged by any defects in the means of



MARTINIQUE. THE CULTIVATION OF COCOA



FILLING A MAIZE RICK

transport that they afford a reliable means of testing modern methods, and anyone who wishes a demonstration of the excellence of these methods ought to visit one of the exhibitions of Colonial-grown fruit held by the Royal Horticultural Society.

Enough has been said to indicate that there is great interest attaching to the ordinary articles which are so familiar to us in every-day life. Some products, such as flour, sugar, and tea, are obtained only from cultivated plants, often grown now in countries far removed from those in which they originally occurred in the wild state. The raw material passes through successive processes before it leaves the land of its production, and after it reaches the country where it is used undergoes other transformations. Other useful substances, on the other hand, are obtained from wild plants, and are collected by primitive and sometimes interesting races, prepared by crude methods, sold at the outposts of some great trading firm beyond perhaps the confines of civilisation, and finally shipped to this country.

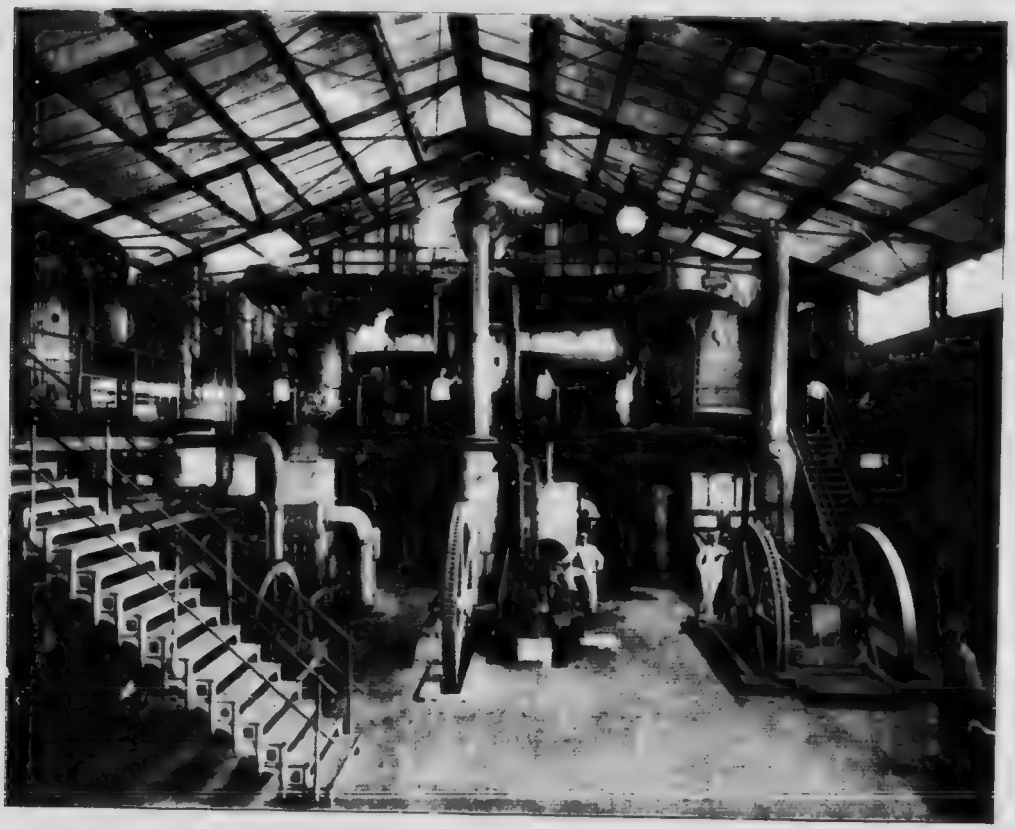
It is obvious that an account of the cultivation, collection, preparation, and uses of the products of every-day consumption cannot fail to be of great interest. Incidentally we learn much not only about the objects themselves, which in itself endows them with much greater interest, but also about the lands of their production and the conditions of life which prevail there.

In this book an attempt has been made to give a general account, on the lines indicated above, of the principal plant products which occur in commerce. The work is necessarily incomplete, because it is impossible in a volume of this size to describe in a manner which

would have any interest all vegetable commercial products. To do this the work would have to run to many volumes. Thus, some years ago, the Government of India produced, under the direction of Sir George Watt, a *Dictionary of the Economic Products of India*. Now, India, although a large country, is small in comparison with the whole world, and yet this work on Indian products alone extends to a monumental series of eight large-paged volumes. A selection has, therefore, had to be made, and, for purposes of convenience, the products have been arranged in natural groups. This method has allowed of general information being given on properties common to all the members of the group, of devoting most space to the more important products, and of mentioning the others in their appropriate places without that detachment often entailed in a book in which each product is treated of separately without reference to its place in a great group.

The results of personal observations in many parts of the world, contributions from experts engaged daily in handling the products under consideration, and the consultation of standard authorities have been blended to make the volume as far as practicable a concise and simple account of the chief plant products of the world. The book cannot hope to be faultless and the magnitude and complexity of the subject treated must be our excuse for any shortcomings.

W. G. F.
S. E. C.



THE ENGINE ROOM OF A SUGAR FACTORY IN JAVA



STRIPPING WHEAT IN CHINA

The World's Commercial Products

WHEAT

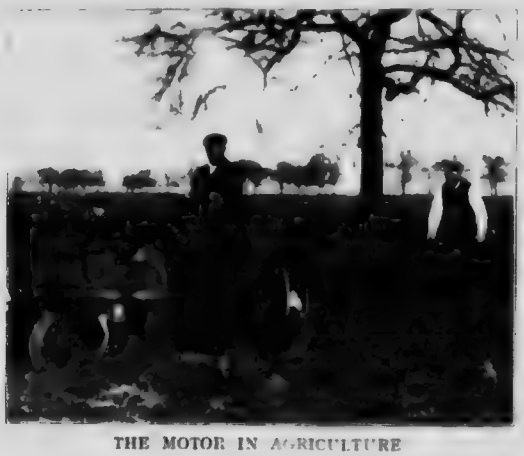
Amongst the World's Commercial Products the first place, if not in actual monetary value at any rate in importance to man, must be given to the foodstuffs on which his very existence depends. In the times before means of transport were perfected, each nation was self-supporting. Indeed, each tribe or even each family collected wild plants, or raised the crops for its own sustenance. This state of affairs still exists amongst the more primitive races. In West Africa, for example, there are near each village the "farms," often worked by all the people in common, where are grown the supplies of Indian corn, millet, cassava or manioc, yams and other edible roots, on which, in addition to the wild products collected in the "bush," the members of the tribe exist. After the harvest the crop is carefully stored either in the field, in special granaries, or in the individual houses to last over the period before the next crop is ripe. No greater injury can be inflicted on a village than to destroy these stores, especially if, in addition, the supply of seed for the next season's sowing is taken away. The natives in Central America, etc., subsist largely on manioc, and a jar of farine, or the meal of this plant, is commonly to be found in each hut. A similar state of affairs was formerly the rule in such countries as Great Britain, and although the advance of civilisation has revolutionised this simple mode of life for the industrial and other sections of the community, we have only to consider the conditions of life of the peasantry of the west of Scotland, parts of Ireland, and elsewhere to realise that even now there are large numbers of families in the United Kingdom practically dependent on their own efforts in tilling the soil for their support.

—C.P.

This, however, is not the case for the majority of the inhabitants of modern civilised countries, who no longer live by direct tilling of the land. To supply their needs foodstuffs must be grown, frequently either in part or wholly in other countries. Some idea of the enormous development of the trade in foodstuffs may be gathered from the fact that the annual value of wheat alone imported into the United Kingdom is about £35,000,000 sterling.

The most important amongst these foodstuffs are undoubtedly the cereals, namely, wheat, barley, oats, rye, rice, Indian corn or maize, millets, sorghum or dhurra, and others less widely used. More than one half the whole population of the world subsists to a great extent on rice, and the vital importance of wheat needs no demonstration.

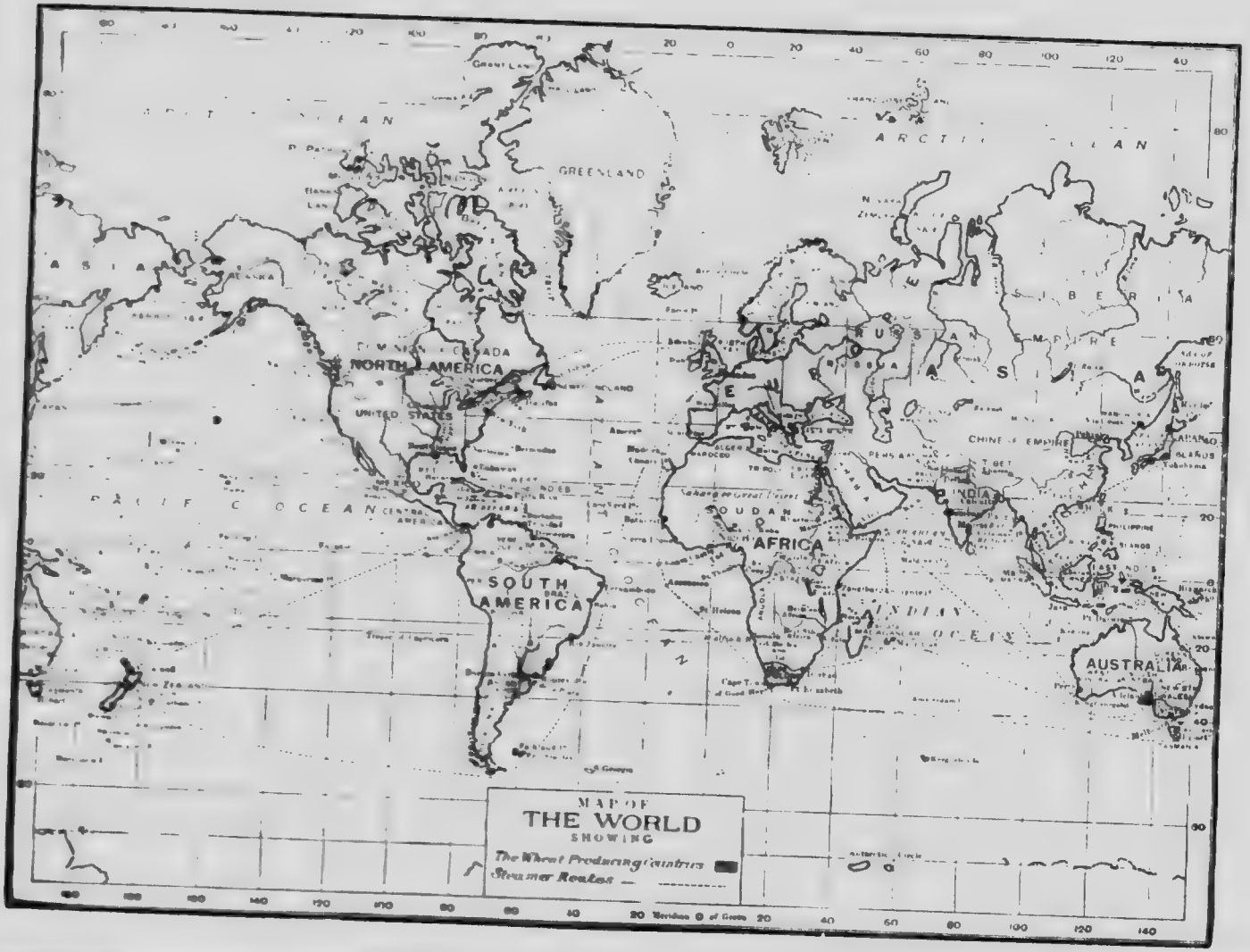
The cereals are members of the great family of the grasses which have been cultivated by man from time immemorial. Originally, no doubt, they were wild plants which attracted attention owing to the comparatively large quantities of foodstuffs they yielded, the ease with which they could be collected, and their edible qualities. Now, in the majority of cases, the original wild forms are no longer known, and as is common with plants cultivated in many lands and during long periods, innumerable species and varieties have been evolved as the result of conscious and unconscious selection by man of the forms which appeared desirable for one or other of their qualities. Their very name—cereals or cerealia—indicates the great value attached to them in early historic times. They are so named after the goddess Ceres, as the Romans called her—Demeter of the Greeks—the patroness of agriculture and all the fruits of the earth. In the temperate regions of the world wheat is the principal cereal grown, and there are many different varieties suited to varying conditions. As we go farther north, barley, oats, and rye increase in importance, and although they are grown for special purposes along with wheat, it is important to note that they will thrive in countries and under conditions not suited to wheat. Starting again from the temperate zones and travelling north or south, as the case may be, we enter the warmer countries where wheat cultivation is often associated with that of rice, maize, sorghum, etc. In the tropics, however, wheat will not thrive at low elevations, but rice, maize, sorghum, and various millets form the great cereal crops, their relative importance varying in different countries.



THE MOTOR IN AGRICULTURE

Sometimes the use of the word "cereal" is extended to include buckwheat and other starch-yielding plants but these are not true cereals. There are also the important starch-yielding plants such as the potato, yam, sweet potato (a kind of convolvulus), manioc or cassava, etc. These all form underground tubers, and are regarded as vegetables, in which section of this book they are discussed. Still another group of starch plants exists yielding arrowroot of various kinds, sago, etc. These are treated in the section on starches and meals.

We will now turn to the consideration of the cereals and deal first with those of temperate countries, and afterwards with those grown in the warmer regions of the world. Of the first group by far the most important is wheat. Throughout the temperate regions of the world are found a considerable number of grasses, either wild or cultivated, which are sufficiently alike for botanists to group them together into a genus and to call them all by the old classical name for wheat, namely, *Triticum*. Three of these wild forms occur in Great Britain, one of


GREENLAND
NORTH AMERICA
UNITED STATES
SOUTH AMERICA
AFRICA
AUSTRALIA
INDIA
MAP OF
THE WORLD
SHOWING
The Wheat Producing Countries
Steamer Routes



A POOR YIELD OWING TO BAD CONDITIONS



WHEAT GROWN UNDER GOOD CONDITIONS

the best known being "couch grass" or "twitch," which is a very troublesome weed in cultivated land. But it has its uses, inasmuch as its long, creeping, underground stems give it the power of binding sand so that it can be planted to arrest the progress of sand dunes, to hold together embankments, etc. These wild "wheat grasses" are, however, of no value as food plants, yielding but little grain. On the other hand, the cultivated species which, for the time, may be collectively spoken of as wheat, are of the greatest importance, yielding the most valuable cereal in the world. Wheats have been cultivated by man from time immemorial, and nothing is now known of the original wild forms from which they are descended. In old legends and ancient manuscripts wheat is spoken of as familiarly as at the present day. Nor do we know with any certainty in which country it was first found; but it seems probable that Central Asia was the original home of the wild forms from which the cultivated species have sprung.

Although we have used the name "wheat" above as including all the cultivated varieties of the genus *Triticum*, this is not quite correct, and before proceeding farther it will be well to give a few notes concerning the various species. They fall into three chief groups:—

1. Small spelt, or one-grained spelt (*Triticum monococcum*).
2. Wheat, including spelt and rice spelt (*T. sativum*).
3. Polish wheat (*T. Polonicum*).

(1) *Small spelt* or *one-grained spelt* is usually characterised by each of the little branchlets of which the ear is composed, containing only one grain, whereas in the other wheats they contain two or more grains. This plant can live in very poor soils, and in stony places not suited to ordinary wheat. As might be expected, it does not grow into such a large plant, the straw being usually not more than from eighteen inches to two feet in height, and the yield of corn is comparatively small. Spain is the chief country in which it is grown, but it is sometimes cultivated in France, Germany, and Switzerland, principally in mountainous

districts. Although it is now little used, its cultivation is of great antiquity, as shown by the finding of grains of this plant in the famous lake dwellings of the Stone Age in Switzerland and Hungary.

(2) *Wheat and Spelts.* The spelts are amongst the grains which have been cultivated from the most ancient times, and they were the chief cereal of Egypt and Greece. They were cultivated by the Romans and distributed throughout the Roman Empire. The plant has decreased in importance, but it is still of great value in the south of Spain, as it is very hardy and can be depended upon to give an average crop even on poor soils. Some of the varieties of spelt have ears like those of ordinary wheat, whilst others are bearded like barley.

Another variety is the two-grained spelt, frequently known by its German name of *emmer*. Starch wheat or rice wheat are other popular names. The ears are usually bearded. Long known in cultivation, it has also declined in favour, and is now principally grown in southern Germany, Switzerland, Spain, Servia, Italy, etc., as a summer grain. There are different races differing in the colour of the grain, which may be white, red, or black. Attention has recently been devoted to this grain as, like the macaroni wheats, it thrives in the dry regions of North America where irrigation is impracticable. This subject is discussed more fully below in relation to so-called "dry farming." The third group includes the true wheats, and these may be sub-divided into four classes.



WHEAT GROWN IN SOIL MANURED WITH PHOSPHATES

(*a*) Common Wheats. This class includes all the most valuable kinds for making bread. Some have ordinary ears, others are bearded; the colour and other characteristics of the grain vary, and innumerable varieties, each with its own name, are distinguished.

(*b*) Dwarf or Hedgehog Wheats. These are low-growing wheats with very short but thick and strong straw. They are grown on poor soils, principally in the Austrian Alps, Wurtemburg, Alsace, Turkestan, Switzerland, and Chili.

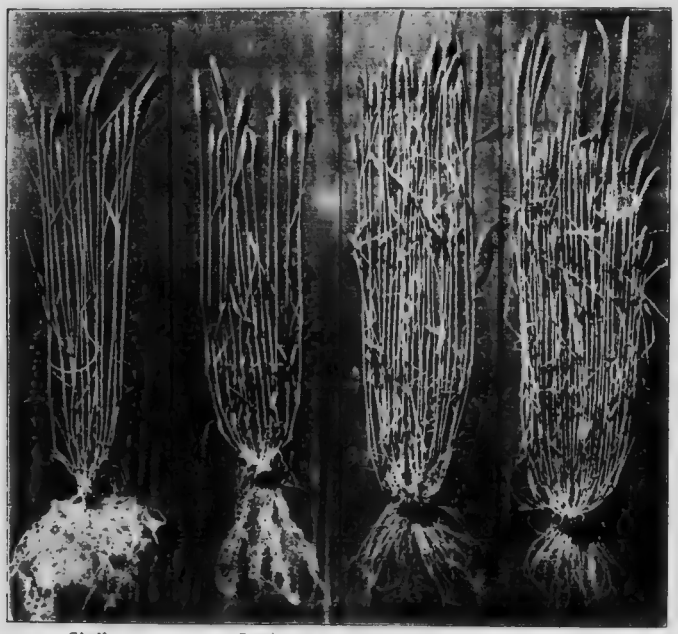
(*c*) English Wheat or River Wheat. Although called English wheat this kind is but rarely cultivated in England, being chiefly found in the countries bordering on the Mediterranean. The flour derived from it is not well suited to making bread, and must be mixed with flour from the kind next mentioned.

(*d*) Hard or Flint Wheat. The ears of this group of wheats are furnished with long, bristly awns. The grain is hard and contains a large amount of the substance known as gluten, which will be referred to later. Flint wheats are most important in Spain and northern Africa. They are of special interest as yielding the best flour for the preparation of macaroni, Italian pastes, etc.

(3) *Polish Wheat.* This, the last member of the wheat group, has large, somewhat flattened, curious blue-green ears, and the straw is often almost solid instead of being hollow like the others. It grows into a large plant, the straw being four or five feet high, but only gives a small yield of grain. This species is supposed to have originated in Spain, in which country it is still cultivated on a large scale.

We will now proceed to describe the general mode of cultivation of wheat.

The soil to which the farmer entrusts his seed must possess certain qualities. Then the plant must be able to extract a sufficient quantity of moisture from the soil, although this need not be abundant. Clays and heavy loams are the best soils on which to grow wheat; but with skilful farming and selection of the proper varieties, good harvests are obtained on light sandy soils. If the ground is too wet, the corn lacks vigour, and the production of seeds is small. If, on the other hand, sand predominates, the ground is too permeable and does not hold the quantity of moisture that is absolutely necessary for the growth of the wheat, which then thrives very badly. It will not do, says the farmer, to accommodate oneself to the soil, but the soil must be accommodated to the plant. When necessary, its nature may be modified by the addition of different kinds of manure, that is to say, by adding the elements which it lacks. Thus, it is necessary to add lime to sandy soils, and as a rule marl—that is, a mixture of chalk and clay—is used for the purpose. If one has to deal with a soil in which clay is lacking, very clayey marl should be taken. The element that is added to the soil must not only modify its physical nature by giving it greater density, or, on the contrary, greater looseness, but it must also, by its chemical composition, increase the chance of successful cultivation. Marl fulfils both these conditions. It sometimes happens that the sub-soil contains the elements which are wanted in the top soil. In that case the land must be deeply ploughed, the sub-soil being brought to the surface and thoroughly mixed with the upper layer. To put the matter briefly, the essential elements are (1) sufficient but not excessive moisture, (2) lime, and (3) the indispensable elements of plant food, such as nitrogen, phosphoric acid, and potash. These elements have to be furnished by natural or chemical manure if it is proved by analysis that the soil does not contain them in sufficient quantities. Thus, the fundamental principle of a rational cultivation of wheat is to know the physical and chemical conditions of the soil thoroughly, a knowledge which enables the farmer to modify its composition in a judicious manner. The great advantage of chemical manures is that it is possible to give greater richness to the soil by the addition of small quantities of material, but they should be used with care. They cannot, however large the quantities added, replace the natural manure, that is, farmyard or, as it is often termed in the tropics, pen-manure. The latter is the manure *par excellence*, improving both the physical and the chemical conditions of the soil, and increasing its water-holding powers, owing to the organic matter or humus it adds.



THE RESULTS OF WHEAT-GROWING UPON VARIOUS SOILS

The land on which wheat is to be grown must be thoroughly cleaned, for the plant is easily choked by weedy growths. Therefore, wheat is usually sown on a field on which a crop has



AN AMERICAN REAPING MACHINE



REAPING IN RUSSIA

been grown which kills the weeds, such as beetroots or turnips in the north, and tobacco in the south.

Different plants have different needs; one requires an abundance of nitrogen, whilst another takes more potash or more phosphoric acid out of the soil. Hence it may be easily understood that if the same variety were grown on one field for several successive years, it would soon have exhausted the element which it particularly requires. Therefore different varieties, which do not require the same elements in the soil, are grown one after the other. This is called rotation of crops. Take as an illustration the Norfolk or four-course rotation: clover or grass is grown the first year, wheat or oats the next, turnips, mangolds, or potatoes the third, and barley the fourth. Sometimes the farmer allows the field to lie waste for a year, without sowing or planting anything, in order to rest the soil. Such fields are called fallow-land. Many other rotations are practised, depending on the character of the soil, climate, amount of stock kept, and special requirements. The soil must be in the proper condition, neither too hard nor too soft. The farmer must try to obtain the golden mean: he must be well acquainted with the properties of the soil, with the climate, and with the capacities of his tools. Hence methods of cultivation differ, according to soil, climatic conditions, etc. The tilling of the soil comprises all operations of which the purpose is either to aërate it, thoroughly to mix its different elements, or to remedy its physical defects. The soil is turned over with the spade, the hoe, or the plough; it is harrowed to break up the clods, and to put it in better tilth, and rolled, if necessary, to give it greater firmness. The importance of these operations varies with the nature of the soil, and with the variety of the wheat grown.

The time when the wheat must be sown also varies according to its kind and according to the part of the world where it is grown. Generally speaking, we may say that wheat does not thrive if the temperature is below about 55° F. for three months or so of the growing period. It is impossible to fix a date for the sowing, for that is a question to be determined by experience, and varies greatly according to local conditions. The farmer must be very careful in his choice of seed. It is of no use to have good land, to till it well, and then to sow seed of an indifferent quality. He can only expect a good harvest when the grains are heavy, well-developed, and thoroughly ripe. Wheat to be used for seed should not be reaped before it is

quite ripe and should be kept spread out on the granary floor as long as possible. In order to obtain seeds which unite all these qualities, the grains from the finest ears are laid aside as soon as the harvest has been threshed: this is the first selection. These grains are first passed through the winnower, which takes out the dust and light grains. Mixed with the corn, however, there may also be seeds of other plants, the growth of which might afterwards do injury to the wheat. These must be taken out: this is the task of the sifter and the bolter. But still the finest-looking grain, having the right weight and the right shape, may, notwithstanding the most energetic winnowing and the repeated shocks of the bolter, contain in the folds of the furrow which runs on one side of the seed the germs of diseases, the spores of fungi which might develop and spoil the whole crop. It is prudent to prevent this by destroying the germs without killing the embryo of the future plant: this is done by liming or by treatment with copper sulphate. In the former process a liquid mixture of lime and water is thoroughly mixed by continual stirring, and poured on the seed, which is energetically stirred with a spade to enable every separate seed to come into contact with the disinfecting liquid. This method is chiefly followed on small farms, but the copper treatment is most generally practised. The seeds are sprinkled with a solution of sulphate of copper or blue vitriol, or preferably the grains are completely immersed in a receptacle containing this solution. Immersion has, in addition, the advantage of allowing a last selection to be made, for the grains which are too light float on the surface and are easily removed. The disinfection should be accomplished little by little, for a heap of wet corn, although it is aired by continuous agitation with a spade, grows warm, and soon commences to sprout.

Wheat is sown either broadcast, by hand or by a sowing-machine, or by means of a drill, which buries the seed in the soil at regular and equal distances. When broadcast sowing is adopted, the harrow is passed over the field, making light furrows into which the seed disappears. But many grains remain on the surface, and are killed by frost or heat, or are picked up by birds. This method is therefore usually only carried out on small farms, where the plot is too small to allow a sowing-machine profitably to be employed.

On large farms sowing-machines are generally used. There are two kinds: (*a*) those which sow broadcast, and (*b*) drills, which distribute the seed over the light furrows or drills they make in the soil, and cover them over at once. The work of these latter machines is perfect, and large quantities of seed are saved by using them, only about half as much seed being required to sow an acre with a good drill as when sown broadcast. The money spent on a good machine is accordingly soon repaid.



A COMBINE ..ER AND HARV..ER

Once the seeds have been buried in the soil, their development begins. About a fortnight after the sowing the first leaves appear: their number increases, and the field looks as if it has suddenly become a meadow, with here and there a bare spot, where for some reason or other the wheat is late, or perhaps does not appear at



STACKING THE CORN FOR FEAR OF RAIN

all. The young plant continues to grow without any check until, with autumn-sown wheat, the frost sets in, and continues again as soon as that is over. If, however, the frost is too severe, the wheat dies and the farmer is obliged to sow summer wheat in March. Again, during winter, the roots may be laid bare. The wheat soon dies if this state of things is not remedied by rolling, which again makes the soil hard and flat. Sometimes, also, the corn comes up bleached or yellow. This is often the case in a cold spring, and very thin liquid manure or nitrate of soda should be added. Very soon its beneficial influence will be seen, and the corn regains its vigour.

But other plants besides the corn take advantage of the nourishing elements with which the soil has been enriched, and if left alone would soon grow up so luxuriously as to stifle the wheat. To get rid of these the field must be thoroughly weeded; when the wheat has been sown broadcast this must be done with the hoe, but when it is sown with the drill the weeding is done with a horse machine.

This rough outline indicates in a general way the methods adopted in sowing and growing corn, but the details vary according to the country and to the extent of the fields, although the object aimed at is always the same. On small farms simple ploughs are used, but on the huge farms of the United States, Australia, Canada, Argentina, ploughs cutting eight or even as many as twenty-four furrows at once are employed. These are either drawn by animals or by steam power. The tilling on these large farms is, of course, done less carefully, but much more quickly. The sowing is carried out with ten or twenty machines, and a whole army of farm-hands work on the fields. Everything is done quickly, and the often still virgin soils are so rich that the harvests are abundant, and all those precautions, which are necessary elsewhere, need not be taken.

The wheat shoots up under the influence of the alternate rain and sunshine of the spring, finding in the soil and in the air the elements necessary for its growth. All the nourishment accumulated by the roots or elaborated in the leaves mounts to the ear and is devoted to the development of the grain. When these have acquired a certain firmness, which the farmer often judges with his finger nail, the corn is ready to reap.

The farmer does not always wait until the wheat is ripe before he reaps it; mowed while it is still green, wheat makes excellent fodder, and in some countries is grown solely for this purpose.

The importance of the different agricultural processes included in the one word "harvest" varies with the extent of the farms. The tools used are not the same everywhere; here men and women wield the simplest kind of reaping-hook, while children follow, gather the haulms, and spread them out on the field to dry. This is the harvesting of small farmers, and this same method is also followed when the wheat has been laid flat by wind or rain. More frequently the reaping is done with the scythe, which works more quickly and neatly.

If the extent of the fields and the farmer's means allow it, reaping-machines are used, which, drawn by horses, cut down the wheat over a breadth of about five feet every time. The

reaping-machine cuts off the haulms and throws them down at regular intervals, and the binders gather two or three of these heaps together to bind them into sheaves. But still more perfect machines exist, which both cut the haulms and bind them into sheaves. These are the self-binding machines, and only one man is wanted to drive each machine. On the immense corn-fields of the Far West, the Americans have for some time been successfully using gigantic, very ingeniously constructed machines, called "harvesters," which, drawn by twenty-four to forty horses, travel through the miles of corn, cutting out a track up to twenty feet wide, reaping, cleaning, and threshing the wheat, putting it into bags, a long line of which it leaves behind. Portable factories we might well call these huge machines, besides which the self-binding machines look like toys. Still larger harvesters are drawn by huge traction engines, and, as giving an idea of their capacity, some of those in use in California cut over forty feet at once, and harvest and leave in sacks ready for export the crop from as much as 120 acres in one day. Eight men are required to work such a machine.

After the harvesting the corn may be taken to the rick or to the barn, but the sheaves must be thoroughly dry, for if heaped up while wet, heat is developed, which causes both corn and straw to ferment, and hence to be spoiled.

After the stacks have been constructed, or the sheaves have been taken to the barn, a privilege which is as old as the world allows the poor people to come and glean the ears which are left on the field. The picturesque silhouettes of the gleaners, stooping over the stubble and picking up the forgotten ears, have often tempted painters and poets.

Threshing, or separating the grain from the ear, is the next process, but as a rule this is not urgent, unless the farmer can obtain a higher price for his corn immediately after the harvest. That part of the crop which is to be kept for seed is reaped last, because it has to be thoroughly ripe, and it is, as a rule, threshed first.

The small farmer threshes with the flail. The cut corn is spread out on the barn floor in a layer about an inch thick, the ears all pointing in one direction, and on these the flails come down at regular intervals. When the grains have been threshed out from the upper surface, the wheat is turned over and the threshing renewed. This work takes a long time and is very exhausting; moreover it is not perfect, for, notwithstanding the thresher's energy, all the kernels are not separated from the ears. But when the corn is threshed in this way the straw is less damaged than when a threshing-machine is used, and on this account such straw is preferred for several purposes.

On farms of medium size another mode of threshing is practised. A thick layer of haulms is spread on the barn-floor; in the middle stands a pole with a leathern strap attached, fastened at the other end to a couple of horses or oxen, which draw a loaded cart with notched wheels. The animals walk round as in a circus, and in this way the strap is wound round the pole, becoming shorter and shorter, so that the cart describes a spiral course on the barn floor, until at last it has been over the whole of the corn. This method is more successful than that with the flail; it is practised



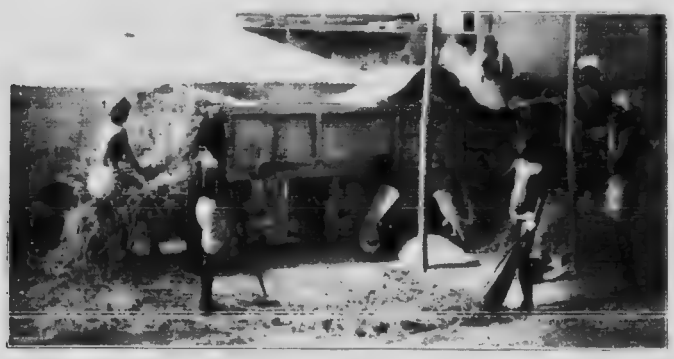
WINNOWING CORN IN INDIA

as a rule in central Europe, in Spain, and also in Algeria and in Egypt. Sometimes the cart is replaced by a many-sided, heavy roller. Wheat is sometimes threshed by driving horses or mules in couples, in fours, or in sixes, in gradually lessening circles, over the barn floor on which the wheat has been spread. This is a very advantageous method as regards the grain, but it has its disadvantages, namely, that the ears and haulms are crushed, and that the harvest is soiled by the animals' excrements.

In China the seed is separated from the straw in a very peculiar manner, namely, by means of large forks or combs, and subsequently spread out on mats to be further trodden out with the feet. The seed is then winnowed and sifted. The winnower is a kind of flat, two-handled basket. The corn is thrown up and caught again to get out the chaff and the fragments of straw. The mechanical winnowing-machine replaces both the winnower and the sieve, and the seeds and other substances which are lighter than the grain are driven out by the action of the fans.

A modern development of this method is found in the combined stripper and thresher, an Australian invention which dates from about the year 1883. A prize had previously been offered in South Australia for a machine which would strip, clean, and bag the corn in one operation, but without success. In 1883 the Victorian Government made a similar offer, and the machine to which the first place was awarded pulled or stripped the ears from the standing wheat, and harvested the grain at the rate of about an acre per hour when drawn by three horses. The straw is not cut at all by this machine but left standing in the field. In 1885 another somewhat similar machine was invented in Victoria, and a third has since been made in Canada. These machines are in general use in Australia, and have recently been introduced with considerable success into Argentina. They pass through the field, stripping the heads from the stalks, the heads are threshed and the grain sifted, cleaned, and passed out into bags much as in a modern threshing-machine. Special conditions are necessary for these strippers to work successfully. To insure the best results, the wheat must be dry, quite ripe, and free from weeds, especially from thistles. Where these conditions are realised the cost of harvesting is estimated from one half to one quarter of that with a binder and thresher. They are not, however, likely to supersede binders altogether, although most valuable when they can be used to advantage.

Threshing-machines consist essentially of rapidly revolving drums, provided with barbed beaters, made of hard wood; they are worked either by animals or by steam or other power. The beaters strike the ears, with which the machine is fed, with great force, the revolutions of the drum sometimes amounting to 800 a minute. Two kinds of threshers may be distinguished, those into which the haulms have to be put perpendicularly to the axis, and those where they have to be pushed in parallel to it. These machines are continually being improved, and notwithstanding the speed at which they work, they perform their task very well. They also winnow and sift the grain, separating the corn from the chaff, and eliminating other seeds, sort, grade, and bag the grain, while the straw, kept back by nets, glides towards a binder, which automatically gathers it into bundles. Sometimes even an elevator with hooked chains



THRESHING IN INDIA



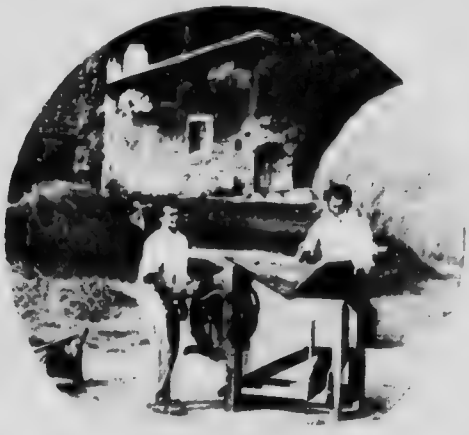
Photo by N. P. Edwards, Edmonton

A MANITOBA FARM

conducts these bundles to the spot where men are building the straw-rick, or a strong current of air blows the straw to the top of the rick.

In North and South America, Australia, and Russia, where the value of the straw is very small, the engines with which the threshers are worked are fed with it.

Some years ago fears were expressed that in the course of a comparatively short time, if the present rapid increase in the wheat-eating people of the world continued without being counterbalanced by the opening up of new wheat fields, or of an increased yield from the existing fields, a wheat famine would ensue. One way of increasing the area under wheat would be by bringing into cultivation lands which do not appear at first sight suited to this crop, such as, for example, the immense tract of country known as the Great Plains region of the United States of America. The rainfall in this region is usually low, perhaps about twelve inches, and irregular, and this, combined with great heat, makes the conditions unsuited to many ordinary crops, and bad harvests often result. Much of this land would give excellent yields if it could be irrigated. This, however, is in many cases absolutely impossible, or if possible the results would not justify the expense.



A SIMPLE WINNOWING AND SIFTING MACHINE

It has been observed for some time that some of the farmers could get good crops, whatever the season, and, in particular, Russian farmers were very successful. This was due to the training they had had in fighting against the cold winters and dry summers of their native lands. Much of the valuable Russian hard wheat is produced in localities where the temperature ranges from extreme heat to extreme cold, and the rainfall is low, perhaps twelve to fifteen inches, or even less.

The Russian farmers brought with them their stock of knowledge, and by adapting their methods to the conditions prevailing in the Great Plains were able to obtain good results, often when the crops of their neighbours cultivated on similar soil and under the same climatic conditions were ruined. Considerable attention is now being given in the United States to these regions, and "Dry Farming" or "Cultivation in Semi-arid Regions" is much to the fore. It is not altogether novel, but rather the adaptation to American conditions of plants and methods successfully employed for a long period in the hard climates of parts of Russia, such as Astrakhan, the Crimea, Turkestan, etc.

The best kinds of wheat for these dry regions are the "hard wheats," which are extremely resistant to drought. Ghirka wheat largely exported from the Volga region of Russia is a good red spring wheat of this class. Another Russian wheat from the Crimea, has, under the name of "Turkey wheat," been cultivated for some twenty-five years in Kansas and other states, and has caused a large increase in the wheat area as it can be grown in places where the severity of the winter rendered wheat culture impossible with ordinary varieties. Still hardier varieties will allow cultivation to be even more widely extended, and steps are being taken to introduce such into the States. Kharkoo winter wheat is regarded as one of the hardiest kinds and likely to withstand the winters of South Dakota and Minnesota.

For resistance to drought as opposed to cold the hardiest wheats are the macaroni wheats, which thrive in eastern Russia, Turkestan, and Algeria under conditions which Mr. A. M. Carleton, who has investigated them, calls arid rather than semi-arid. These macaroni wheats



REAPING ON A SMALL FARM



STEAM ENGINE AND THRESHER IN ROUMANIA

are also very resistant to rust and other diseases, and they give heavy yields. For instance, in seasons of great drought, macaroni wheats in the States have given twice and four times the crop of ordinary wheat under the same conditions. They are, however, liable to be killed by cold, and so in many cases can only be used as spring wheats.

Having obtained seed of the right class of wheat it is essential to cultivate it under the best conditions, and all the skill and attention of the farmer is in this case directed to conserving the small quantity of moisture his land receives as rain. The cardinal principles are to have the subsoil well "packed" to hold all the moisture possible, and to keep above this well compacted stratum a layer of loose earth. The loose earth prevents the loss of water by evaporation, and care is taken repeatedly to harrow this top layer after every shower of rain. Macaroni wheat, emmer, and also other cereals thrive well under these conditions, and give large returns, as much as thirty, forty, and even more bushels per acre being recorded. Properly developed, the results of this practice will be very far-reaching, as there are enormous areas in the States alone suitable for this type of cultivation, but on which ordinary wheats, cultivated on ordinary lines, could not possibly thrive.

The straw of wheat excels all other kinds of straw, because it is much stronger. It is, therefore, by no means an unimportant product of the wheat-harvest. It is used for seating chairs, and stuffing straw-mattresses, while straw-carpets, string, bee-hives, baskets, and other objects of wicker-work are made from it. The bearded wheat of Tuscany is often cultivated especially for its straw, of which hats are made, generally known as Leghorn hats, after the place of export. Straw is also used for thatching the roofs of cottages and barns.

Wheat straw, usually mixed with other food or with the wheat grain, is a useful fodder. Straw that has served as litter for horses, pigs, or cows makes excellent manure.

Wheat, after it has been separated from the ears as well as when it was still in them, has numerous enemies. We immediately think of rats, mice, and birds. But there are many more quite as injurious—small animals such as weevil grubs, which penetrate into the corn, and live and multiply in it. To guard against these animals, firmly built, well-ventilated barns are wanted, without any fissures or chinks, in which the small pests might hide. It is preferable not to have a wooden floor but one of cement, and the walls should also be cemented up to a certain height; the air-holes in the roof should be protected with wire to keep birds out. After all these precautions have been taken, the corn may be safely heaped up in the barns, but not higher than about two feet. Now and then it should be turned over with a spade to air it.

Large industrial firms which must have room to store considerable quantities of wheat have iron rooms for the purpose, in which the development of heat is prevented by mechanical stirring and proper ventilation. In Africa and in Asia the wheat is sometimes kept in subterranean siloes. These siloes are pits or vats dug out in the soil, which is very firm and dry by nature, or they are improved by coating them with cement: their dimensions are sometimes considerable, and to these the farmers take the grain that they have not sold.



THRESHING WITH OXEN



PLOUGHING WITH OXEN

The Americans, whose immense farms produce enormous quantities of wheat, often store away their harvests in such siloes to await the hour when it is likely to fetch the highest price in the old world. In Chicago large storehouses have been built where the corn is stored until the large steamers come to the quay to be loaded. These vast storehouses are often provided with special machines to transfer the grain quickly into the holds of the cargo-boats. The wheat of the south of Russia is stored at Odessa, and this port owes a great deal of its activity to the exportation of corn.

Wheat is used for other purposes besides bread-making. In the industrial world it plays an important part in the manufacture of spirits and of beer. Starch is also prepared from it, and a special variety is grown for the purpose.

MANUFACTURE OF FLOUR. To be of value for human food, the grains of wheat must be ground to flour. In olden times, when the men did nothing but go out hunting or wage war against one another, the women and slaves diligently pounded the wheat in a hollowed-out wooden block, which served them as a mortar. As people's tastes became more and more refined, however, the millers' tools were improved. Millstones, made out of hard round stones, and describing circles on a circular surface, also hollowed out in hard stone were used, and later the invention of the watermill and the windmill reduced the labour.

To this day we see mills in the country moved either by water or by the wind. But the windmills, which looked so picturesque with their big vanes, are now fast disappearing, even in the Netherlands, where they used to be one of the chief characteristics of the landscape. The running water of a brook or a small river is a more regular motive power than the wind. But whatever may be the motive power, a mill which works by means of millstones consists essentially of a flat circular stone, about two yards in diameter, horizontally fixed on a wooden frame. The centre of this stone is pierced by a firm iron or steel bar, which is the pivot on which a second millstone, resembling the first, freely turns. Formerly each millstone was in one piece, hewn out of a very hard kind of stone. They are now often cast out of gravel and sand, and are of an extraordinary degree of hardness. A series of radial grooves is, as a rule, cut out in the surfaces of the millstones, in which the meal collects and is driven away from the centre by the revolving motion of the upper stone; in this way the grains are gradually ground to meal. There are several pairs of millstones in one mill: the distance between the stones of each pair differs, and the grinding is repeated several times in order to obtain the largest quantity of flour. The number of small millers is becoming less and less; the small mills are gradually being replaced by large factories where tons of corn are daily

ground to meal. In large factories millstones are replaced by revolving steel rollers, which pulverise the corn. This coarsely ground corn passes through several other machines, where it is bolted and sifted, in order to separate the meal completely from the bran. The final pair of revolving rollers through which the bran is passed to get out the last particles of meal are made of porcelain. Thus, the work of these factories consists in successive or alternate grinding, bolting, and sifting. The flour obtained by these processes has attained an almost incredible purity, and is completely free from all foreign elements, such as dust, germs, or bran. The flour used for the French "pain de luxe" is obtained from a special kind of hard corn.

In addition to being used for different kinds of leavened bread, of which we shall speak later on, wheat is employed for several kinds of unleavened bread; such as, for instance, the unleavened bread which the Jews eat at the Passover, the wafers of the Roman Catholics, etc.



REAPING IN PERSIA

Several sorts of baby-food are also prepared out of flour, and pastry and fancy cakes; and then there are different kinds of rusks, and numerous varieties of dry biscuits.

A great deal of wheat is also used for the preparation of pastes. These are made of the hard macaroni wheats, which contain a high proportion of the sticky gluten. Macaroni and other pastes are made from semolina, the small rounded grains into which the hard wheats are broken up instead of being ground into the fine powder of ordinary flour. These pastes are commonly called Italian or Genoese pastes, and are known to the French as "pâtes alimentaires." They are dry and have different forms, and are used in puddings, soups and ragouts. The best-known of these pastes are vermicelli and macaroni, which are made by forcing the semolina, kneaded with water, through small cylinders or pipes, whence it takes a tubular form.

These small tubes are manufactured in enormous quantities in large kettles; a great many holes are pierced in the bottoms of these kettles and the thickness of the tubes depends on their diameter. In order to make the macaroni into tubes, that is to say, to make them hollow, steel wires in the form of a U are passed through every two holes, and inside the kettles all these wires are connected with one another, to keep them exactly in the centre of every hole.



A PRIMITIVE BAKERY

The tubes are cut off as near as possible to the holes. Then they are dried in the open air, usually in the dusty streets or on the roofs of the houses in Naples, before they are packed in boxes and exported to various parts of the world. Although originally an Italian industry, immense quantities are now made in large factories in Marseilles and other parts of France.

Bread in all its different forms plays an important part in the nourishment of mankind. It is true that one nation eats more bread than another, but this depends more on custom than on geographical or economic conditions. Bread is, comparatively speaking, a cheap kind of food, which most people can afford, and thanks to the rapid means of communication between the different parts of the world, it is sold almost everywhere.

The general method of making bread is known to everyone and need not be described.

The United Kingdom has a special interest in the production of wheat in the world, as it is by far the largest importer of this product. The annual value of the wheat imported is about £35,000,000. This was not always so, and if we go back two and a half centuries we find that Great Britain not only grew enough to supply its own wants, but was able also to export considerable quantities. Then followed a period of about a century during which the imports were comparatively small, that is to say, the production was but little below the consumption. At the present time scarcely more than one-fifth of the annual supply is grown at home, the remainder being all imported from abroad, mainly from the United States, Argentina, Canada, India, Russia, and Australia, the relative contributions of each varying according to good or bad harvests and other circumstances.



GRAIN ELEVATOR

Europe is the principal wheat-growing continent, producing more than half the total supply of the world. North America with the great wheat fields of the United States and Canada takes the second place, yielding about one-third to one-half of the crop of Europe. Asia, chiefly owing to India, is third, and then follow South America, Australasia, and Africa in the order named.



BREAD READY FOR DELIVERY

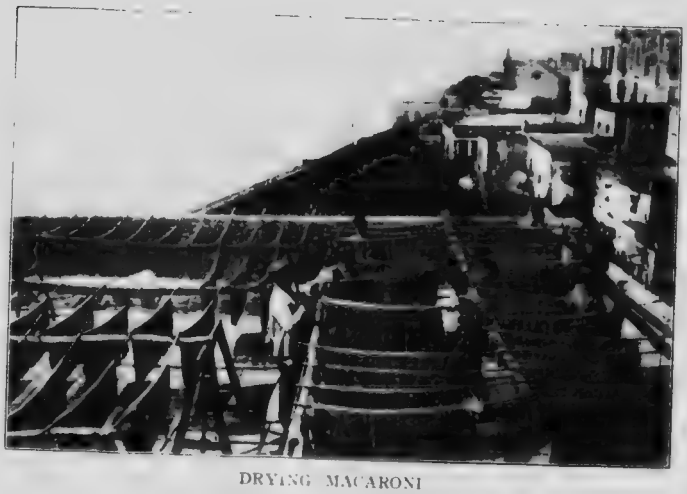
In 1905 the wheat crops of the continents were approximately:

	bushels		bushels
Europe	1,790,693,000	South America ..	175,120,000
North America ..	808,674,000	Australasia	65,626,000
Asia	456,135,000	Africa	41,500,000

The chief individual wheat-producing countries for the same year were:

	bushels		bushels
United States of America	692,979,000	Argentina	154,420,000
Russia	676,435,000	Germany	135,947,000
France	338,785,000	Canada	109,695,000
British India	281,263,000	Spain	83,605,000
Austria-Hungary ..	227,646,000	Australasia	65,626,000
Italy	160,000,000	United Kingdom ..	62,059,000

BARLEY



DRYING MACARONI

BARLEY is a most important cereal crop, and the hardiness of the plant enables it to be cultivated in higher latitudes than any other cereal. Its cultivation, however, is by no means confined to cold regions, for among some of the most important barley-producing countries of the world are France and Turkey.

As is almost invariably the case with plants which have been long cultivated by man, the number of varieties existing at the present day is very great. They are generally reduced by botanists, however, to four species, viz., (1) Common or two-rowed barley (*Hordeum distichum*); (2) Bigg or Bere (*Hordeum vulgare*); (3) Six-rowed barley (*H. hexastichum*); and (4) Fan or battledore barley (*H. zeocriton*).

As a cultivated cereal, barley is of great antiquity, and Pliny has placed on record his opinion that it is the most ancient foodstuff of man, a statement to which modern research lends considerable support, for in the Lake Dwellings of Switzerland, which belong to the Stone Age, no less than three kinds of barley have been discovered, and identified by Professor Heer as varieties of the two-rowed and six-rowed forms mentioned above. Up to within comparatively recent years bar[illegible]ened an important article of food in northern regions, but the ever-increasing use of [illegible]s supplanted it to a very considerable extent in the more prosperous countries, wh[illegible]bitants prefer the more palatable and dainty bread made from wheaten flour. Nevertheless, the nutritive value of barley is considerable, the chief objection to its use being the comparative poverty in gluten, the valuable compound found abundantly in wheat, which enables the flour to yield a vesiculated bread.



DRYING MACARONI

In Britain the use of barley as a bread corn is confined to Scotland, where unleavened barley cakes still form an article of food of the peasant class, though far less than in former times. For this purpose the barley is passed between the rollers of a mill to remove the outer hard cuticle from the grain, which issues from the

rollers as "pot barley," and if the grinding is carried still farther the grain is reduced to "pearl barley," so largely used for domestic purposes.

At the present day, however, barley is largely raised in order to supply the malt for brewing purposes. Enormous areas are under cultivation for this cereal in Europe, especially in Russia, Germany, France, and Turkey, and, as is well known, it is one of the most valuable crops in Great Britain.

In Russia the crop is chiefly grown in the northern districts, extending right up to the shores of the Arctic Ocean, and large quantities are also raised in southern Russia, but very little barley is grown in the central districts.

Malting has for its object the production of a ferment known as diastase, which possesses the property of converting starch into sugar. Barley, in common with other grains, contains a large amount of starch, which during the germination of the seed is converted by the ferment diastase into sugar, and this, in the ordinary course of nature, is utilised by the seedling as food. In the preparation of malt, the barley is soaked in water, and then allowed to germinate in a favourable temperature until the diastase is fully developed, which occurs when the rootlets are about two-thirds the length of the grain. The germinated barley when dried is known as malt, and after being coarsely ground in a mill it is placed in a vat into which water is allowed to run, the whole mass being carefully stirred to extract the starch and the diastase. In the subsequent "infusion" process, the malt is raised to a temperature of about 140° F., by pouring boiling water into the vat, and, after about four hours, the starch has been converted into sugar by means of the ferment. The conversion of the sugar into alcohol and carbon dioxide is effected by adding brewers' yeast to the liquid, which is drawn off into separate vessels, and, when the fermentation is complete, the alcohol is obtained as such by distillation.

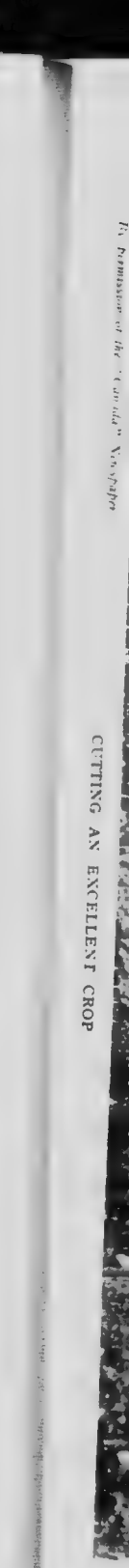
Great care is exercised in selecting the grain for fermentation, and the barley should be free from chaff, quite fresh, and in fine large grains of a bright colour.

RYE

As in the case of other cereals it is doubtful whether rye (*Secale cereale*) exists in a wild state. It has been described as occurring as a weed in the wheat fields of Afghanistan, and is found apparently wild in Turkestan, but the best evidence goes to show that the true home of the plant is in the regions around the Black and the Caspian Seas, an assumption which is supported by the fact that five or six known species of the genus *Secale* inhabit western temperate Asia, or the south-eastern districts of Europe. The cultivation of the plant appears to be of comparatively recent origin, for, unlike barley, for example, no specimens of the grain have been obtained from the Swiss Lake Dwellings, and De Candolle mentions that it has not been found in the Egyptian tombs. These



A MACARONI-FACTORY



CUTTING AN EXCELLENT CROP



By permission of the "Canada" Newspaper

CUTTING AN EXCELLENT CROP



EXPORTING CORN FROM ODESSA

circumstances are interesting when taken in conjunction with the fact that rye is a comparatively "constant" plant, there being but few varieties, a point in which it strikingly differs from most other cereals.

In Great Britain rye is chiefly grown as a forage crop when it is cultivated at all, but the quantity raised is very small. In Russia, however, rye is by far the most important cereal, and immense quantities are raised in Scandinavia and northern Germany, where rye or black bread is so important an article of food.

The annual production of rye in Russia is greater than in any other country, and the average quantity raised, namely, about 650,000,000 bushels, is nearly twice the average annual wheat crop. The distribution of the area devoted to rye cultivation is exactly the reverse of that given over to barley, for while the latter cereal, as stated above, is grown chiefly in the northern and southern districts, rye is principally cultivated in central Russia, where barley is seldom met with. The soil of the northern and eastern districts is peculiarly well suited to rye, and the Government of Vyatka takes first rank in production, the annual crop averaging about 45,000,000 bushels. Practically all the rye grown by the Russian peasants is sown in the autumn, but in Siberia, especially in the Tomsk and Tobolsk governments, a large part of the seed is spring sown. The peasants to a great extent still adopt very primitive methods of cultivation, and the seed is usually sown by hand, covered with a simple harrow, and, when ripe, generally harvested with sickles.

OATS

OATS (*Avena sativa*) have never been found truly wild, and it is a matter of considerable difficulty to determine upon any locality as their original home, while attempts to identify a particular species, as the parent form from which the modern varieties have sprung, have signally failed. This state of affairs is due in no small measure to the readiness with which cultivated oats establish themselves upon waste ground, often persisting in such a way as to appear wild. For this reason De Candolle, in his "Origin of Cultivated Plants," throws considerable doubt upon the reputed existence of truly wild oats in Persia and the Sinaitic peninsula; though he admits that the more frequent occurrence of the semi-wild or naturalised condition in the Austrian states, from Dalmatia to Transylvania, lends additional support to the theory, advanced upon philological and historical grounds, that the probable home of the oat was in the temperate countries of eastern Europe, and in Tartary. A curious opinion, said to have been based upon certain statements of the navigator Anson, which met with considerable support during the eighteenth century, was to the effect that the oat was originally obtained from the famous island of Juan Fernandez, but unfortunately for this view oats have been found in the Swiss Lake Dwellings. Further, from historical records it is known that the cereal was cultivated in very early times to the north of Italy and Greece, and in the face of

WHEN THE BARLEY IS RIPE IN CASTILE



By permission of the "Canada" Newspaper

HARVESTING THE FIRST CROP

such evidence it is highly improbable that the original home of the plant would be so remotely distant from the countries where it was anciently cultivated.

The "bristle-pointed oat" (*Avena strigosa*), which has been regarded by some authorities as the origin of the Scotch oat, is found in fields in Europe which have been thrown out of cultivation, a fact which confirms the opinion that it is but a variety of the common oat, and not an independent species. Another form of oat (*Avena orientalis*) has been cultivated in Europe for upwards of 150 years. As the name indicates, the plant comes from the East, being known in Germany as the Turkish or the Hungarian oat, and it is often mixed with common oats, from which it is not easy to distinguish it on cursory examination. A most interesting reference to the oat is made in a Chinese historical work dealing with the period 618-907 A.D. The oat referred to is the "naked oat," known to botanists as *Avena sativa nuda*. It has been found wild around Pekin, and the botanist Lindley has declared that the "pilcorn" of the old agriculturists, which was cultivated in England during the thirteenth century, was no other than the naked oat.

Oats form one of the most valuable sources of food for both man and beast, the nutritive value of the grain being very high. It is extensively grown in Britain and on the continent of Europe, the Russian oat crop being one of the most important in the country. There are also enormous areas in North America devoted to this crop.

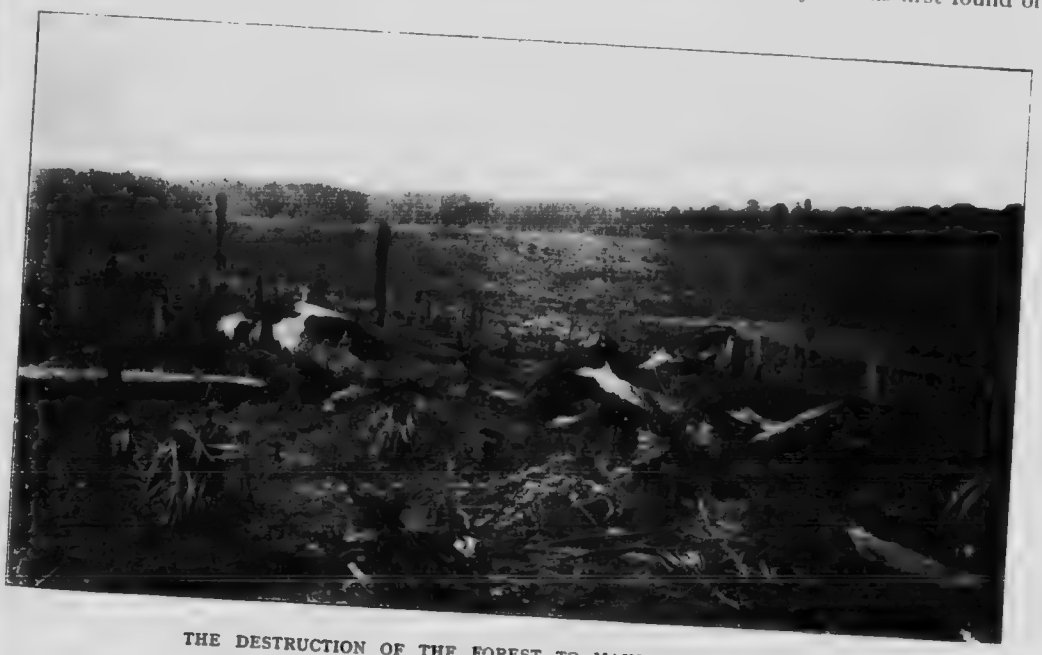
The importance of oats as a fodder for stock, especially for horses, is well known, and the straw itself is a valuable constituent of chaff, but perhaps the most important use of the cereal, from a popular point of view, is as the source of "oatmeal," so extensively used for domestic purposes. Oatmeal is obtained by grinding the kiln-dried grain from which the husks have been previously removed. The meal can be baked into "cake" or "biscuit," but owing to the difficulty of rupturing the starch grains contained in it, except at very high temperatures, the meal does not lend itself to bread-making

RICE

WHEAT is the most important cereal in Great Britain, Europe, Canada, the United States, Australia, and indeed throughout the greater part of the temperate zone of both the old and the new worlds. Barley, oats, and rye are also important, and in certain localities exceed wheat in this respect, whilst rice in these same countries is of minor importance, and is regarded more as a material to be made into puddings, etc., than as a staple article of food.

In the tropical and sub-tropical regions the case is very different, especially in densely populated countries where agriculture is the principal means of livelihood for the mass of the people. In all these countries rice is the "staff of life," and, as a matter of fact, rice is the principal food of about one-half of the whole population of the earth. Amongst the more important of the rice-eating countries are the Chinese Empire, with a population of 400,000,000, British India, 300,000,000, Japan, 50,000,000.

The cultivation of rice extends back into the dim past, and there are no authentic records as to when it first began. Its original home was in south-eastern Asia, but it has been cultivated for many ages, and introduced into almost every part of the warm region of the world, so that it is extremely difficult to be certain in which country exactly it was first found or



THE DESTRUCTION OF THE FOREST TO MAKE ROOM FOR RICE



SOWING THE SPROUTED RICE IN SIAM

cultivated by man. Evidence points to the Chinese having been amongst the earliest people to cultivate rice, and such great value was attached to it that in the annual ceremonial sowing of important plants, inaugurated by the Emperor Chin-nong so far back in the past as 2,800 B.C., the rice had to be sown only by the Emperor himself, whilst the four other plants of the ceremony might be sown by the princes of his family. In India rice has been cultivated from time immemorial. Theopurastus mentions that rice was grown there, and the Greeks probably first became acquainted with it during the Indian expeditions of Alexander the Great. It was introduced at an early period into Syria, Egypt, and other parts of Northern Africa. In more modern times rice has spread into Spain, France, and Italy, the first cultivation in the last-named country being stated to have been near Pisa in 1468.

The plant is believed to have been introduced into America in 1647, when Sir Wm. Berkeley raised a crop of sixteen bushels from half a bushel of seed. A second introduction took place in 1694, when an English boat homeward bound from Madagascar put in at Charlestown through stress of weather. The captain paid a visit to the then Governor of Carolina, Thomas Smith, whom he had previously met in Madagascar. Smith expressed a wish to try to grow some rice in a swampy piece of land in his garden, and the captain gave him a small bag of rice which he happened to have on board. The site of the garden is still pointed out in Charlestown. The experiment proved a brilliant success, and was the beginning of the flourishing rice industry of Carolina.

Asia is the most important rice-growing region of the world, for excepting in the northern portion of this continent, rice is universally cultivated. Three-quarters of all the rice that comes into the markets of the world is grown in British India, Bengal producing the greatest amount. Siam, China, Japan, Java, the Straits Settlements, Ceylon, the Hawaiian Islands, and other Asiatic countries all produce large quantities of rice, although not sufficient in every case to supply the local demands.

In Africa the chief rice-producing country is Egypt, owing to the very favourable conditions prevailing in the Nile valley, and the natural annual flooding of the lands. The French colonies of Senegal, the French Sudan, Madagascar, and Réunion cultivate it extensively and rice is also grown in Mauritius, and along the coasts of both East and West Africa. On the whole, however, Africa does not possess such large tracts of land naturally suited to rice as occur in Asia.



PLOUGHING A RICE FIELD IN ASSAM



TYPICAL RICE FIELDS

Rice is of minor importance in Australasia, although grown to a considerable extent in New South Wales, Queensland, and in the Sandwich Islands among other places. In Europe, Italy is the chief seat of rice cultivation, and is the only country on the continent in which the production is greater than the local demand. It is estimated that in the valley of the Po there are about 800,000 acres under rice, producing some 27,000,000 bushels annually. Spain, Portugal, and Greece follow next in order of importance, whilst even in France, in the valley of the Rhone, the plant is cultivated.

In North America rice is an important crop in the United States, the centres of production being Louisiana, Georgia, and South and North Carolina.

Comparatively recently, due in great measure to the introduction of East Indian labourers, rice has been cultivated to a considerable extent in British Guiana, British Honduras, Trinidad, Jamaica, and St. Lucia. British Guiana offers the most favourable conditions, and instead of the small patches of a few years ago thousands of acres are now under rice cultivation on the coast lands. Rice may yet become one of the important crops of the Colony.



CEYLON. ELEPHANT DRAWING A RICE PLOUGH

The rice plant belongs to the great tribe of the grasses just as do wheat, barley, oats, Indian corn, and the other cereals. The scientific name of the plant is *Oryza sativa*, but as is the case with most plants which have been cultivated for long periods, and on an extensive scale, there are a large number of varieties, the descendants of the original wild stock. These varieties sufficiently resemble one another to be classed as rice, but in the countries in which they occur each has its own particular local name, and differs from other varieties in size, shape, and colour of grain, in the time taken to ripen, in cooking qualities, in flavour, and in various other particulars, just as do the different kinds of wheat. In the museum at Calcutta there are no less than 1,107 different varieties of Indian rice, in addition to 1,300 kinds from other countries. In Ceylon some 160 varieties are recognised, and the Straits Settlements and the Federated Malay States possess a considerable number. In Japan and China there are numerous varieties, so that altogether the kinds of rice recognised and distinguished by separate names in the East must be reckoned in thousands. The courts of the Eastern Colonies at the Imperial Institute, London, will allow anyone readily to see many of these. In addition to the true rice there is a closely related plant bearing a very similar seed, but which, instead of being mainly composed of starch, contains a more sugary material, so that on boiling, the grains do not remain distinct, but form a soft sticky mass of a



BRITISH INDIA. AN IRRIGATION PUMP WORKED BY THE FEET

distinctly sweetish flavour. In the Straits Settlements this grain is known as "padi," and in Java as "ketan." It is the product of another species of *Oryza*, namely, *Oryza glutinosa*, and many varieties of it are known.

The rice plant, when growing, looks very like wheat or any other cereal, but, instead of having a compact "ear," bears a head composed of a number of fine branches or stalks, each of which bears one grain. These are easily detached, and are covered with a brown husk, and this unhusked rice throughout the East and in other parts of the world also is known as "padi" or "paddy"; after the husks have been removed the white grains then set free are called rice. It is convenient therefore to distinguish between unhusked rice, or "paddy," and husked rice, which is the form in which it occurs in European markets.

In addition to the various varieties mentioned above, rice plants may be broadly divided into two main groups, "upland" or "hill" rice, and "wet" rice. Upland or hill rice includes those races which can be cultivated as any ordinary crop, whereas wet rice has to be sown under such conditions that it can be kept flooded for a great portion of the growing period.

With these preliminary observations we can proceed to describe in detail the methods of rice cultivation practised in various parts of the world. Where civilisation has penetrated least, the cultivation of rice is managed in a way which would seem very reckless indeed to the eyes of a farmer who is obliged to get as much out of the soil as he possibly can. There are parts of the East which are still entirely covered with virgin woods. There we find tall trees. Underneath it is dark; the foliage of the trees intercepts the light. The quiet of death reigns there, and nothing is seen of the animal world up in the tops of the trees. The plants grow up slender and tall, longing for light and air. Creepers are climbing upwards, winding themselves round the trunks of the trees, making the woods impenetrable for those who do not carry a knife to cut their way through. The most beautiful orchids are said to live on those trunks, but they also want their share of the sunshine, and often grow so high that they are not easily seen. Where the fall of a tree has made a gap in the roof of leaves, through which light and air are again able to reach the soil, small brush-wood at once begins to shoot up, struggling to keep the spot thus acquired.

The races who inhabit these regions live chiefly on rice and divide the year according to the occupations which their simple methods of cultivation entail. With the new year they begin to cut down the trees. In the thick wood a suitable spot is chosen; wood is of no value in the midst of that luxurious vegetation. It is rice they must grow and for that the trees are sacrificed. Everything is got rid of in the easiest manner. Copses and brush-wood are cut down and spread out to dry. Then comes the turn of the ancient trees. High and heavy, often of hard wood, some are of such a breadth at the base that it is no use to attack them there. Ladders are made and the giants of the forest are assailed at a point higher up where their trunks are less bulky.

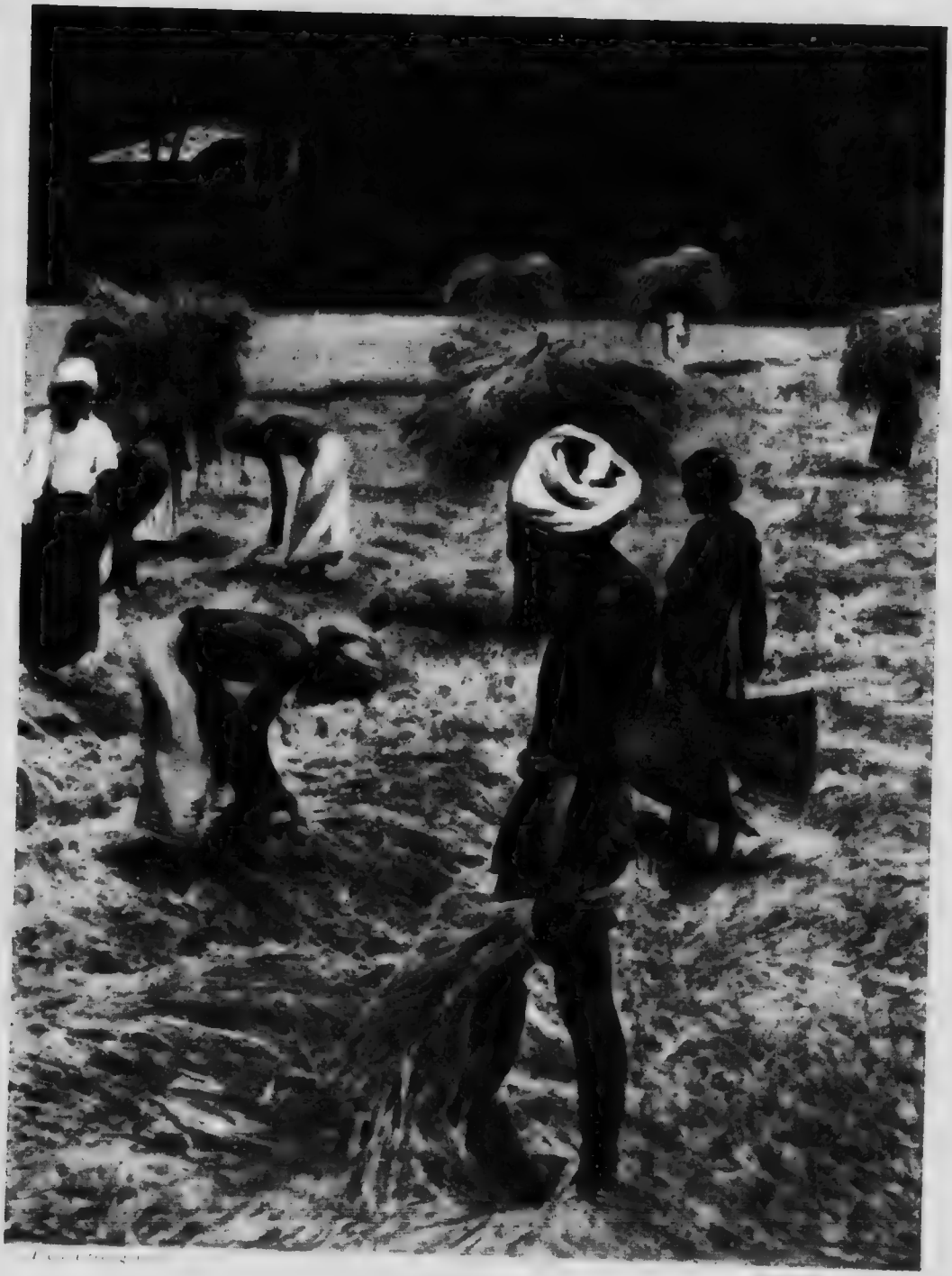
After this everything is burned as far as possible. The primitive farmer uses the wood that can be removed, piling it up as a hedge round his field. The thick tree-stumps, hardly attacked by the fire at all, remain; the felled trunks which resisted the fire he simply leaves lying where they are. These are often nearly fifty yards long and so enormous that a grown-up man cannot look over them.

Now the rainy season is coming when the sowing must begin. The cleared spot has to be dug, and sometimes trenches are made. A small guard-house is erected, for all sorts of animals might otherwise make short work of the harvest, or perhaps even eat the sown seed. There are the elephants, very fond of rice plants, and capable of trampling down the hedge; deer, boars, monkeys, and other animals, who would deprive man of his harvest without the least respect for his hedge of half-burned wood.



A SIMPLE METHOD OF IRRIGATING A RICE FIELD IN SIAM

When all this is ready the people get out their planting-sticks. In the civilised world a planting-stick is a simple piece of wood without any external characteristic. After long use it has perhaps been polished by the rough hand of the field-labourer. But here it ranks higher, as one of the few agricultural tools. It is sometimes very long, so that he who uses it need not stoop. It is made of very hard wood, ebony, perhaps, for it must be strong enough not to break against the roots, which are left in the soil, and it is ornamented as such an important tool should be. In the holes made with the planting-stick are put a few seeds of the kind of rice that grows in dry soil, covered with earth, and pressed down with the feet. If rain is abundant there is a chance of a good harvest. A second crop may perhaps be obtained from the same ground. Then the field which has been cleared with so much trouble and at the cost of so many fine trees is abandoned. The people wander to another part of the wood, there to make a new clearing. The old one with its chopped trees, still standing, and its big trunks rotting on the ground, is left to nature. The tropical



GATHERING RICE

vegetation at once takes possession of man's inheritance; insects and fungi attack the dead trees; the wild animals, driven away by the fire, return to their old haunts, until after many years, the forest, which has meanwhile grown up again, is once more cleared in the same way.

In this manner is rice cultivated in countries where the population is scarce, land is abundant, and wood of no value.

Elsewhere people prefer planting rice in fields, which may be flooded or kept dry at will.

In Ceylon anyone who travels, even rapidly, through the country cannot fail to notice the wonderful development the rice industry has attained under the care of the Sinhalese. The railway from Colombo, on its way up country, passes first across a great stretch of level land, with, frequently, scarcely anything to be seen on either side but broad expanses of rice. At



PLANTING OUT THE YOUNG RICE PLANTS

the proper seasons of the year when the plants are young, a delicate green tint prevails, more delicate even than a young field of wheat. All these fields are enclosed by low banks of earth, so narrow that it requires a little care for a European in boots to walk along them, but which the native with his bare feet easily traverses. On each side of the earth banks is the mixture of mud and water in which the rice plant thrives. The object of the earth banks is, of course, to allow water to be admitted at will to the fields, and retained there whilst required for the growth of the plant.

After some miles, the railway begins to ascend the central mountain mass towards Kandy, the ancient capital. It might be thought that the steep sides of the hills would limit the cultivation of rice. But this is not so. With infinite care and skill the natives have cut away and transformed the continuous slopes into terraces, so that sometimes we see a whole hillside of perhaps several hundred feet fashioned into broad steps, each with its raised earth bank to

retain water to a depth of a few inches. Frequently in natural hollows, where all the sides have been terraced, the general effect is that of a huge amphitheatre, which, when the crop is standing, appears, at a distance, to have been overgrown with moss.

Water must be available at the highest level of the rice-field, and is led on to the first terrace, whence in time it trickles over the earth bank on to the second, and so on, so that the whole hillside from top to bottom is converted into a series of very shallow pools separated by low vertical steps. By diverting the stream, the rice-fields can be dried for purposes of harvesting, etc. Those who look upon all natives in the tropics as indolent and without initiative might have reason to modify their opinion somewhat if they saw some of these terraced rice-fields which have required enormous, persistent, and well directed action for their formation, and demand constant care for their maintenance in good condition.

If it is not possible to flood the rice-fields in a natural way, by admitting the water from a stream, the flooding has to be accomplished by artificial means. A simple way is that followed by the Chinaman, whose rice-field is more of a garden than an actual field. With his mate he takes his stand on the little dike separating his plot from the water at a lower level. Together they repeatedly let down a small wooden bucket on one side into the water, draw it up, and empty it on the other side on a mat, placed over the young plants to prevent their being washed away, whence it flows on to the field. If the field is too large to irrigate by hand, he uses a sort of chain-pump, worked either with a treadmill by men or by a buffalo. A similar machine is also used in Siam.



HOEING RICE IN JAPAN

In the Highlands of Java, where a rapidly flowing stream can be used to flood fields situated above the water-level, the people are very clever in making the stream itself force the water up to the height required. A paddle-wheel is made of bamboo cane and twigs, consisting of an axis, to which two big felloes are fastened by means of spokes. These felloes are mutually connected by pieces of bamboo, open on one side and closed on the other by the partition always found in bamboos at every joint. The bamboo buckets are fixed on the felloes in such a way that on the side of the paddle-wheel going up they are placed with their opening upwards, the natural consequence of which is that on the other side the situation is reversed, that is, the opening is downwards. The stream pushes against the bamboo-buckets and causes the wheel to turn, while the buckets fill themselves. Having passed the highest point, they empty themselves into a simple gutter constructed by the wheels' side, through which the water flows on to the field.

In China, as already mentioned, rice is held in high esteem. Every year the soil is worked with great pomp and solemnity by the Emperor himself, assisted by a number of princes and high functionaries, before his subjects. To the Temple of Heaven and Earth at Peking belongs a field which is reserved for this ceremony. In the spring the "Son of Heaven" ploughs about four furrows there with a beautifully ornamented plough, drawn by an ox. With other ploughs his courtiers and high officials make a number of furrows, the number increasing as their rank decreases, until finally the work is finished by some forty field labourers, who have been found worthy of this honour. The field is then sown with the



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STEAM THRESHER AT WORK IN A TEXAS RICE FIELD, PREPARING THE CROP FOR THE MILL



HARROWING IN JAVA TO GET RID OF THE WEEDS

five holy plants: millet, rice, wheat, barley, and beans, the Emperor himself sowing rice. The crop is gathered under the supervision of a high official, and used on particular occasions, as, for instance, for offerings to the ghosts of the Emperor's ancestors. In the provinces this same rite is observed by the viceroys, indicating how highly agriculture is esteemed in China. Yet agriculture in the European sense is but little practised in China; the country is too densely populated, and the land too much cut up into small holdings. Agriculture has been changed, so to speak, into horticulture, and in most cases the plough has had to give way to the spade. Notwithstanding, China is probably the country in which the largest quantity of rice is grown, although not enough to supply home demands, so that an additional amount has still to be imported. The export of rice from China has been prohibited for centuries.

Cultivation. Although the methods employed in different countries vary in detail, the object sought is the same in each case, the formation of fields to which water can be admitted and retained at will, so as to provide the rice plants with the most favourable conditions for their growth.

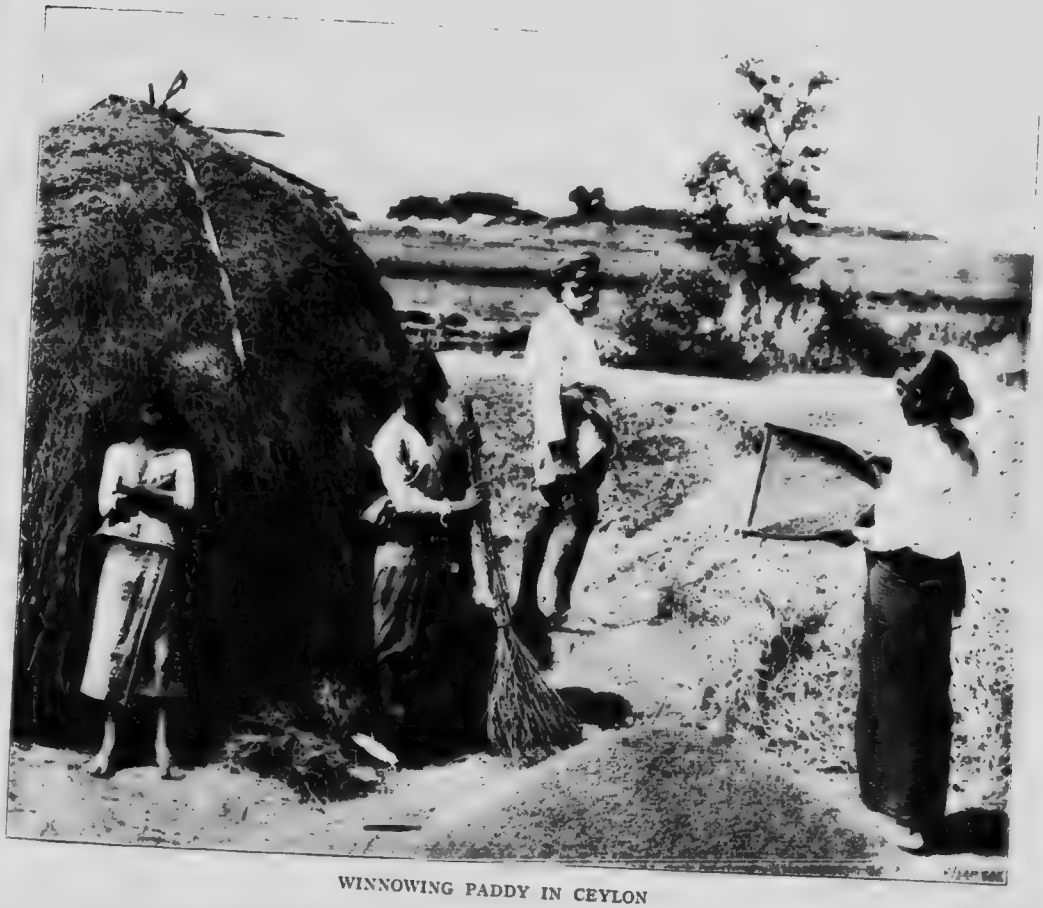
Throughout the East the mode of cultivation is essentially similar, and as the growth of rice in other lands, such as British Guiana, Mauritius, etc., has been taken up by Indian coolies, a general account of Eastern methods will suffice to indicate how rice is grown over a large area of the world. Then having described in a general way this more primitive method, we can turn to rice cultivation in the United States, where, as in the case of other crops, science has been called in, with successful results, to aid man's labour.

The small fields, each with its surrounding earth bank to retain the water, are carefully worked with primitive implements—hoes, spades, or mattocks—sometimes simple ploughs are used drawn by men, by buffaloes, or even by elephants (pp. 29 and 30). It is often urged against these primitive tools that they are ineffectual compared with modern agricultural implements. It is true they often do little more than stir the surface soil, but in some cases where, on European advice, ordinary ploughs have been used, the result has been to go too deep and break through the "pan," which prevents the water from draining away through the soil, so that the field has been spoilt. Improvements can, of course, be made, but the problem is not so simple as often appears at first sight, and the true method of advance in the East and elsewhere is probably to be attained rather by gradual modification of native tools than by radical alterations. Moreover, the conservatism, often well justified, of the agricultural labourer is well known throughout the world, and is developed to the greatest extent in the Oriental.

The seed is sometimes sown broadcast in the fields, but frequently special seed beds are prepared. In these the soil is tended as carefully as in a garden bed.

Surrounded by its ridge of earth, water is let in until the whole bed is of the consistency of fine mud. The seed is often soaked previously in water for two or three days until it has begun to sprout, and then sown very thickly over the seed bed, now covered with water to a depth of a few inches (p. 28). In a few days the young plants are well established, and then the water is drained off the bed during the day time and run in again at night. This has the effect of keeping the young plants warm at night, and allowing air to reach the plants during the day, at the same time preventing them from being burnt by the sun, which may occur when they are covered by a very shallow layer of water.

When the plants are nine or ten inches high, they are pulled up and set out in little groups in the fields which have meanwhile been prepared and flooded to a depth of a few inches (p. 33). At first the water is alternately let in and run off, but when the plants are thoroughly well established and actively growing the field is kept continually flooded. The water must not be allowed to become stagnant, so a very gentle circulation is maintained, the water slowly escaping from the lowest point in the field, and more allowed to enter from above to take its place. On terraced lands the overflow from the top little field or step of the terrace runs over on to the second, and from the second to the third, and so on down to the bottom of the valley. As in the case of wheat, the commencement of ripening of the crop is known by an alteration in colour, and at the proper moment the water is drained off, and the field gradually dries until the rice is ripe.



WINNOWING PADDY IN CEYLON

As mentioned before, some kinds of rice can be grown without being flooded with water. These are usually grouped together as "Upland" or "Hill Rice." They are cultivated in much the same manner as any other kind of corn, and do not call for any special description in addition to that already given.

Let us now direct our attention for a short time to the methods employed in the United States of America, where rice is cultivated on modern principles. The United States, with their great range of climate, can grow all the more important cereals, wheat, barley, Indian corn, oats, etc. They grow these on such a scale as to supply all their own wants and to have an enormous quantity for export, but as regards rice, although a very large amount is grown, a great deal has to be imported. The difference is due partly to rice only growing in the hotter regions, and partly to its requiring flooded land on which it is difficult to use modern



THE JAPANESE USE A PECULIAR FAN TO WINNOW PADDY



MEN HUSKING RICE AT BANGKOK, SIAM

harvesting machinery. Hand labour thus becomes necessary, which in the United States is enormously more expensive than in the tropics.

In Carolina, Georgia, Florida, and Mississippi, there are large areas in the river deltas, etc., which can be flooded at high and drained at low tide. Arrangements are easily made to regulate the water supply, and rice is grown in much the same manner as in the East. Hand labour is necessary to a large extent, and these naturally favoured [illegible] produce less than one-twentieth of the rice grown in the United States, although South Carolina has been famous for the high quality of its rice for perhaps two centuries. Comparatively recently—about 1880—a great prairie region in Louisiana and Texas was opened up and, where water was available, was found to be suited to rice cultivation. Accordingly, with the aid of deep wells, powerful pumps, and elaborate irrigation canals, naturally dry prairies are flooded at will to allow rice to grow. But it is important to notice that when the water is run off, the lands are left sufficiently dry to allow ordinary harvesting machinery to be used. In this region, therefore, instead of having to reap rice laboriously by hand, up-to-date reaping and binding machines drawn by mules are employed, with an enormous reduction in cost.

In 1904 this region produced twenty of the twenty-one million bushels of rice grown in the United States. Modern steam threshing machines are used, and every detail of the industry carried out under as good conditions as in the case of wheat or any other cereal, so that rice can now be grown in Louisiana and Texas at a cost actually less than in China, although a man's wages in China are only about one-twentieth of those paid in the States. This is due to the fact that with hand labour in China one man cannot cultivate more than about one or two acres, whereas in Louisiana or Texas with the aid of machinery one man can cultivate about eighty acres.

Harvesting. The crop is reaped by cutting the stalks in practically the same way as one would reap wheat. The instruments used vary in different countries, and sometimes the

"ears" are cut off separately, leaving the straw standing. When cut the crop is tied up into bundles and placed to dry on the field, or piled up on the earth banks or arranged over bamboo poles. The crop may now be stored in barns, or in a stack, to be used as required, just as wheat is not necessarily threshed immediately it is reaped, but may be kept for months in the ear. In some countries special rice store-houses are constructed for the careful preservation of the crops.

The grains are removed by some simple form of threshing, or by drawing the stalks through a narrow slit so that they are pulled off. Each grain is now separate and covered by the outer brown or otherwise coloured husk. Rice in this state is called paddy, and may be, and often is, stored in this condition, as it is found to keep better in the tropics than when the husk is removed. Thus it has been noticed that the disease "beri-beri" more frequently attacks the men of a village, away perhaps on a hunting or other expedition, than the women who remain at home. Although nothing is as yet known with certainty on the matter, it is not improbable that the outbreak of the disease may be due to the condition of the rice eaten. The women at home can pound daily the rice they require, whilst the men take a supply of cleaned rice to last the whole time of their expedition. This cleaned rice, being stored for some time, is much more likely to become infested by the fungus which appears to play a part in bringing on beri-beri than the small quantities prepared daily, and hence indicates the wisdom of storing the grain as paddy. Accordingly, in eastern villages where rice is one of the staples of food, the next process—the husking of rice—takes place daily, enough being husked each day to supply immediate wants. The usual process is very simple: a small quantity of the paddy is placed in a wooden or stone mortar and pounded with a pestle or with a large wooden mallet. As will be seen from the illustrations, pestles and mortars vary greatly in pattern and size in different countries, but the principle is the same. Pounding rice is a very characteristic sound in the East, and is often done to a certain rhythm. The blow from the pestle or mallet cracks the outer husk, and sets free the rice grain which was inside. To separate the grains from the husks or chaff some form of winnowing is adopted. A simple way is to fill one of the curiously shaped baskets—really broad, shallow scoops—see pages 37, 38, and 45, and toss the contents in the air, when the grains fall immediately to the ground, whilst the light husks are carried some little distance by the wind.



THE WINNOWING MACHINE IS NOT UNKNOWN IN JAPAN

Natives in many parts of the world have displayed considerable ingenuity in devising simple machines to save themselves labour. Sometimes a heavy weight is fastened to a beam so arranged that by stepping on the end of the beam the weight is raised, and by stepping off it is released to deliver its blow on the paddy in the mortar (p. 47). Other devices allow buffaloes to be employed, whilst, with greater advancement in mechanical ingenuity and available

A NATIVE RICE BARN IN SUMATRA

water-power, man or, perhaps more frequently, woman was released from all the drudgery, and the whole process carried out by a self-acting machine. Such water-power rice mills are very common in Japan, but in the towns steam power is employed, the process, however, remaining essentially the same as in the more primitive methods.

Crude as these methods may seem, the rice is not very much broken or damaged by the pounding, and the grain is more nutritious and of much better flavour than the more elaborately prepared, but beautifully white product, which alone finds favour in European markets. This is due to the fact that the rice after harvest in many races does not go through the subsequent process of polishing referred to in the next paragraph under commercial milling.

Commercial Milling. The commercial milling of rice is quite complicated in comparison with the simple methods employed in the East. All impurities being removed, the paddy is passed under closely set millstones. Blowers separate the grain from the chaff. The grain is now pounded in huge mortars or passed through an iron "huller" containing a revolving shaft with projections, where the inner skin is removed. The waste material from this process is rice bran. Finally the grain is polished by friction against cylinders covered with very soft sheep or other skin. At times foreign substances appear to be added to improve the appearance of the grain, because, as has quite recently been pointed out in *The Analyst*, the examination of a large number of samples of rice showed that polished rices contained "ash," ranging from about ·5 to about 2·25 per cent. This ash appears to be due to the employment of talc, French chalk, etc., in the polishing. No harm need arise from its presence as it is removed during the process of cooking. Another way to get rid of it is to soak and wash the rice well in water before use. During the process of polishing the outer part of the grain is removed, and is known as rice polish. It is unfortunate that custom or fashion demands a beautifully smooth, pearly white rice, because this outer portion contains the fats and other highly nutritious parts of the rice. Indeed, it is estimated that the rice polish is nearly twice as nutritious as polished rice itself. Native rice as obtained in the East, although not so white as polished rice, has much greater food value, and moreover is of better flavour. At present rice is classified in the market and its price assessed on its appearance, and, as has been well remarked by Dr. S. A. Knapp in his interesting paper on *The Present Status of Rice Culture in the United States*, "if rice is to enter largely into the list of economic foods for the use of the masses, grades must be established based on the food values and not on the shine of the surface. It



PREPARING RICE IN THE PHILIPPINES



CLEANING RICE AT MANILA

with rice and help to compensate for its deficiencies. In the East, curry and rice is a national dish; the rice is the principal item in the bill of fare, the curry being little more than a flavouring material added to make the dish more tasty. Small quantities of meat, dried fish, etc., are cooked, together with a sauce containing turmeric, capsicums, or peppers, and various other ingredients, and eaten with the rice. The relative proportion of the two constituents is frequently reversed in the East and in England. In India, for example, a small quantity of the curry serves to render palatable a large amount of rice, whilst here we rather add a small portion of rice to the curried meat which we regard as the staple of the dish. Endless varieties of curries are made in India, and those of Ceylon are also exceptionally good, as the fresh milk of young cocoanuts is frequently employed in their composition to a considerable extent. The West African negro, both in his native

would be just as sensible to place a price on shoes according to the polish they will take."

Uses of Rice. The principal use of rice is, of course, as a food, and, as already noted, it forms the staple diet of about half the population of the world. Rice, in its natural unpolished condition, is one of the best of the cereals, better even perhaps than wheat, because it does not contain the large quantities of gluten which, although of great use in allowing bread to be made from wheat, is of comparatively little value as a foodstuff, since the human body appears unable to utilise gluten to advantage. Proof of the high nutritive value of rice was afforded during the Russo-Japanese War, in which rice formed a very important part of the diet of the Japanese soldier. Great care was taken to serve the rice properly, and interesting accounts are on record of "rice balls" being distributed to the men during the heat of an engagement. Peas and beans grow readily throughout the tropics and are commonly used in conjunction with rice; they are, of course, rich in proteids, although not in the form most readily digested by man. They are, however, extensively used



CHILDREN POUNDING RICE IN INDIA

country and also in the West Indies, does not make curry in the Eastern manner, but he frequently renders rice more appetising by boiling with it a piece of salt fish, or salt pork, large quantities of which figure in the list of imports of a community with a negro population. Rice cannot by itself be made into bread as it contains very little gluten. But it has the great advantage of being very easily digested, and is often of great benefit to invalids who cannot readily take starchy vegetables, such as potatoes. The Eastern people cook rice very nicely so that each grain is separate and firm, and the mass can readily be handled. In Europe rice, too often, is served as a sticky mass, due to improper cooking.



DIVISION OF LABOUR IN BRITISH INDIA

The straw of the plant is a fairly good fodder for cattle. It is plaited and made into hats, the straw shoes of Japan, and other items of apparel. The husks or chaff are useful for manure and in a variety of other ways. Rice bran and the mixture of broken grains, dust, etc., are valuable cattle foods. Rice polish is the most nutritious of the by-products from the milling and cleaning of rice. Possibly, in the future, fashion may not demand the removal of the most valuable part of the grain, but at present it is chiefly used as a cattle food.

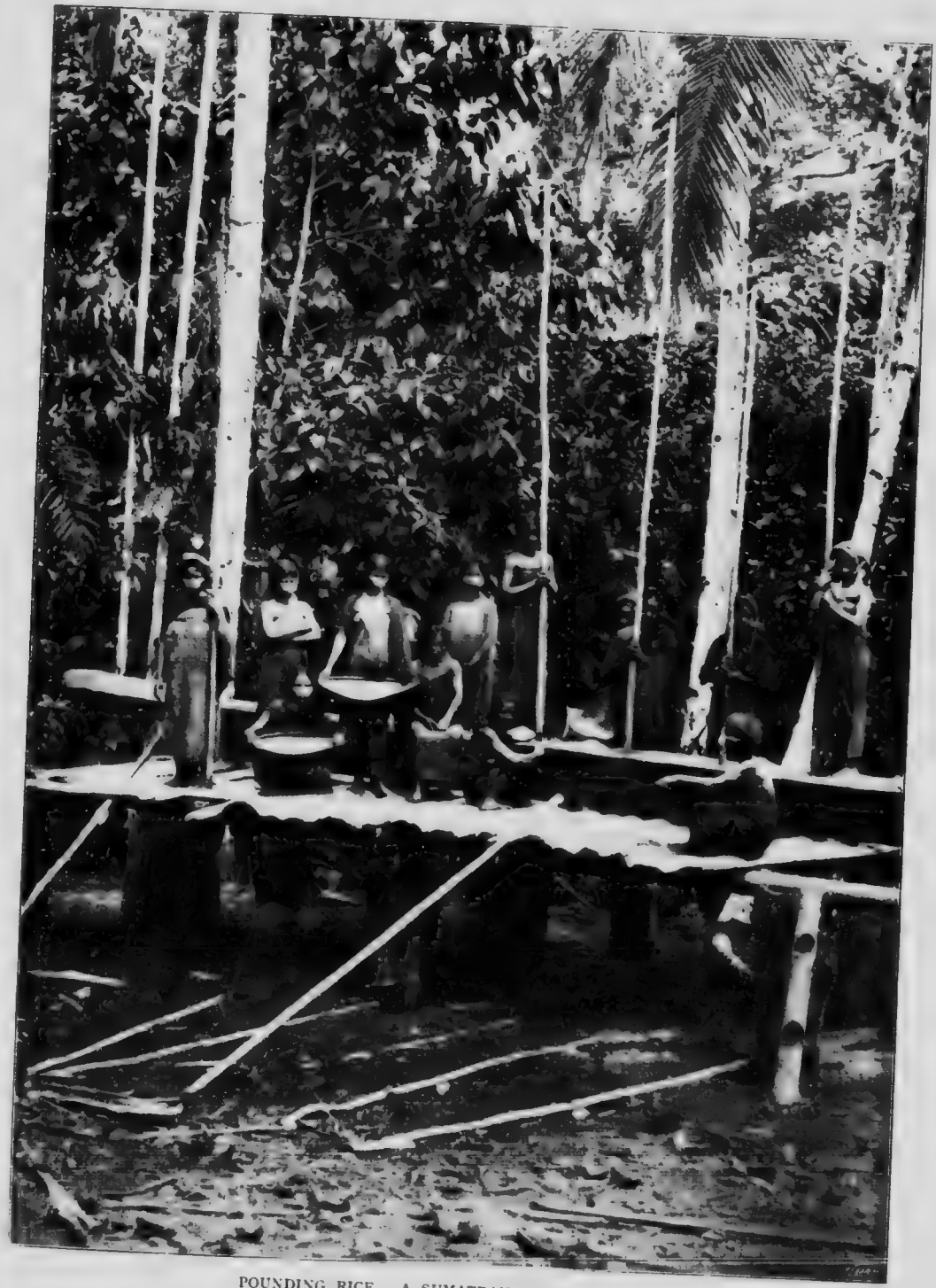
Poudre-de-riz—one of the requisites of the toilet table—is not made from rice, but of soap-stone finely powdered. In India, however, a rice powder is prepared from the grains for similar purposes.

Starch is made in Europe from rice not required for other purposes, some is exported again to India to be used in "making up" cotton prints. (*See* Starches.)

Alcohol from Rice. The Japanese prepare from rice an intoxicating liquor known as "Saké," which is said to resemble in taste light sherry, kept in a beer-bottle for some time. A certain ferment, called "koji," which in reality is nothing but mouldy rice, is used in its preparation. In order to obtain this, some previously soaked rice is steamed until all the grains have become soft. The whole mass is spread out on mats to cool, and sprinkled with the spores of a fungus called *Aspergillus oryzae* and placed in a cellar. After twenty-four hours a white mould begins to appear on the rice, which at the same time grows more and more sticky, and green spots begin to show themselves. The mass is stirred up about every twelve hours and water added, and in from three to four days the preparation of the koji is finished. It may be dried and packed in tins, and kept a considerable time like German yeast.

Saké is prepared as follows: During four or five days ten parts of water, three of koji, and seven of steamed rice are stirred in a bowl with a wooden spoon. The mixture is poured into another vessel and covered with a mat. The first fermentation now takes place, and lasts from ten to twenty days, depending on temperature.

Fifty parts of this fermented substance are taken and 150 of boiled rice, and 200 of water



POUNDING RICE. A SUMATRAN VILLAGE SCENE

added to it. The whole mass is stirred five or six times a day with the big wooden spatula, at which the second fermentation immediately begins, and is checked after five or six days by pouring the liquid into another vessel. In about twelve days the saké is ready for use. The whole preparation thus takes about a month. Saké is sold in casks which in their turn are again packed in a straw cover, so that they resemble bales of rice. Saké contains about thirteen per cent. of alcohol; the Japanese usually drink it hot out of very small porcelain cups. It is sold in bottles of porcelain, earthenware, or glass. The Japanese drink saké at the beginning of a meal, and it is an important beverage at weddings.

The Chinese also prepare an alcoholic drink from rice containing about thirty-six per cent. of alcohol, and made in less time than the saké of the Japanese. In Java an arrack is made from rice by the action of a substance known locally as "raggi," the active agent in which is apparently another kind of mould. The Dyaks in Central Borneo also prepare a sort of arrack from rice.

WILD RICE

OVER a large area of the United States, Southern Canada, and also in Japan, Formosa, and China, there occurs, usually in sluggish streams and along the edges of lakes, a tall grass known as the Wild Rice plant, and botanically called *Zizania aquatica*. It has been estimated by the botanists of the United States Department of Agriculture that this plant



JAPAN. MAKING USE OF THE BAMBOO TO LIGHTEN THE LABOUR OF HUSKING RICE



A JAPANESE MACHINE FOR POUNDING RICE

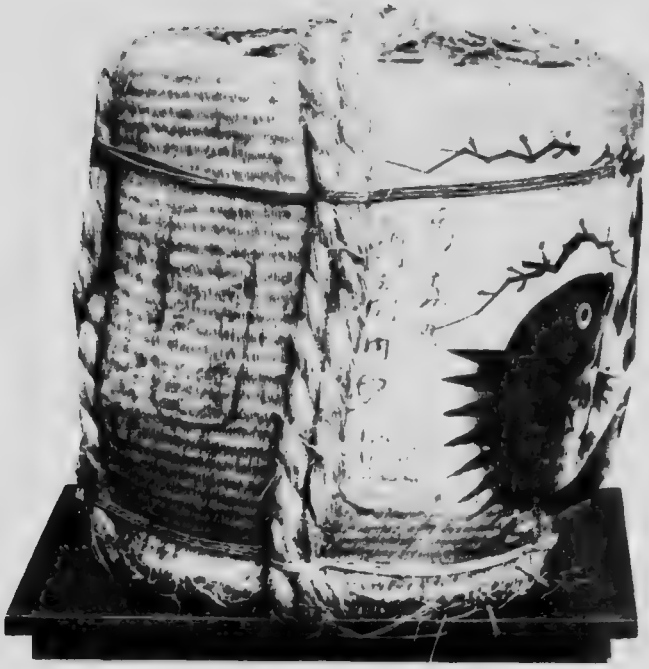
is an important, if not the chief, starchy food of 30,000 American aborigines, as well as the principal fattening food of myriads of wild fowl. It is to a small extent placed on the American market as a breakfast food.

The plants thrive best on muddy soil covered with a good depth of water. The seeds from one crop fall directly into the water, strike the mud, and afterwards germinate. The upper parts of the fully grown plants stand out above the water, and the Indians go harvesting in birch-bark canoes. One man paddles the canoe, whilst the other, seated in the stern, gently pulls over the edge the plants growing on either side, and beats off the ripe seed into the bottom of the canoe. Each patch is gone over several times to gather the grain in the best condition.

The seed is then taken ashore and either spread out to dry, or immediately prepared for hulling. This is done by heating it in a kettle over a slow fire which makes the outer husk brittle and easily broken. After this parching operation the seed is allowed to cook, and is then pounded, the grain being separated from the hulls or chaff by tossing it in the air as described for rice. In this state it can be stored for a long time, whilst the fresh seed is very soft and rapidly spoils.

Analysis shows that wild rice closely resembles rice, barley, and wheat in chemical composition. It has a peculiar flavour, and is eaten, cooked with wild fowl, as a breakfast food. To a certain extent also, it is used in the manufacture of rice cakes.

The cultivation of the wild rice plant presents certain difficulties, and many planting experiments ended in failure from causes which until recently were not well understood. In the first place it has been ascertained that the seed rapidly loses its vitality, and special precautions have to be taken to guard against this. The second factor is the degree of saltness of the



JAPAN. A BARREL OF SAKÉ WRAPPED IN RICE STRAW

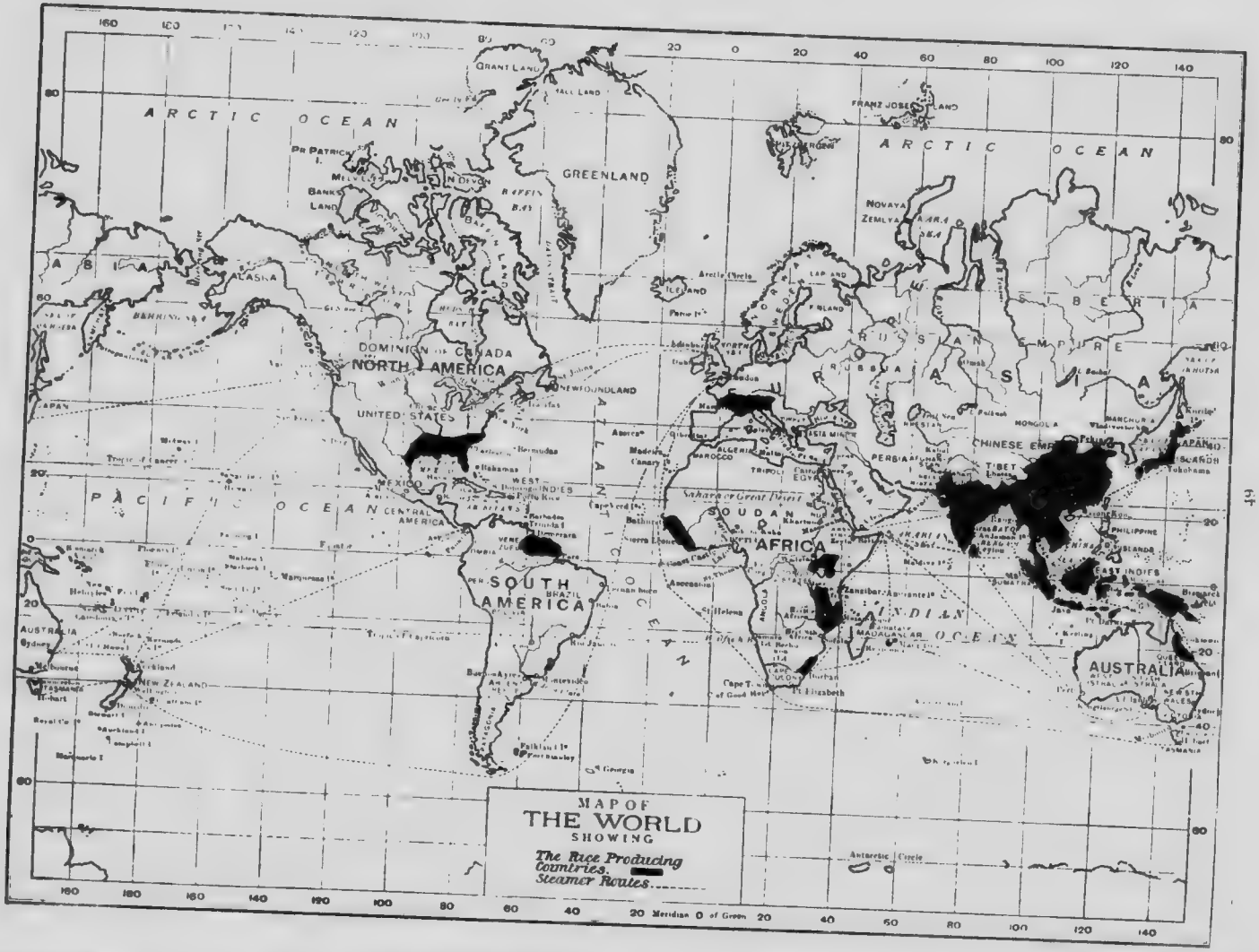
water. Wild rice is naturally a fresh water plant, but it will thrive on marsh lands, mud flats, and similar places which are alternately covered and left bare by the tide, provided the sea water is sufficiently diluted by the addition of fresh water. Very careful experiments were conducted by one of the officers of the United States Department of Agriculture to determine exactly the limit of salinity. He found that the sense of taste is a sufficiently accurate guide. Water which is appreciably salt to the taste is not suited to the successful cultivation of wild rice, and areas exposed to such water, however promising they may appear otherwise, should be avoided by the would-be cultivator.

The plant also occurs in China and Japan, and in the former country is known as Kau-sun. It is extensively cultivated along the margins of lakes and streams, but it appears to be but seldom allowed to flower and form seed, as the Chinese appreciate the vegetative portions of the plant rather than the grain as a food-stuff. The very young shoots and the solid bases of the stems are collected, lightly boiled, and eaten as a vegetable.

In Brazil and the West Indies another species of *Zizania* is reported to occur and to be used to some extent by man for food and for fodder. With proper care wild rice or Canada rice, as it is also called, could no doubt be cultivated in suitable localities in the United Kingdom.



JAPAN. MAKING UP RICE IN 136 LB. BALES, COVERED WITH RICE STRAW


ARCTIC OCEAN
GREENLAND
DOMINION OF CANADA
NORTH AMERICA
UNITED STATES
PACIFIC OCEAN
SOUTH AMERICA
AUSTRALIA
AFRICA
SOUDAN
ATLANTIC OCEAN
INDIAN OCEAN
RUSSIA
SIBERIA
CHINESE EMPIRE
JAPAN
EAST INDIES
MAP OF
THE WORLD
SHOWING
The Rice Producing Countries.
Steamer Routes.



PRIMITIVE BUFFALO PLOUGH

MAIZE
OR INDIAN CORN

THIS valuable food-stuff is the grain of a gigantic grass known to botanists as *Zea Mays*. The origin of the plant is wrapped in mystery, and has given rise to considerable discussion, the question at issue being whether *Zea* is a native of the Old World or of the New. In his comprehensive monograph of the plant the great French agriculturist, Bonafous, upheld the theory of an Asiatic origin, but his opinion was contested by De Candolle, who considered the evidence upon which an Eastern origin of the plant was based to be quite insufficient and to a certain extent misleading, and further stated that the true home of maize was America, and that the plant was only known in Europe after the discovery of the New World. There can be little doubt that the bulk of the evidence is in favour of De Candolle's view, for while it is impossible to find any traces of the plant in the Old World before the fifteenth century, either in actual remains or in historical records, there are, on the other hand, indisputable proofs of its great antiquity in the American continent. Soon after the discovery of America, travellers found the grain in the ancient tombs of the Incas, and although the civilisation of the Sons of the Sun probably does not date back previous to the Christian era, the fact indicates that maize was even at that remote period a recognised food grain. A yet more remarkable proof of the antiquity of the cereal in America is afforded by the discovery by Darwin of ears of maize buried in the soil of the shore in Peru to a depth of eighty-five feet, and this fact taken in conjunction with the absence of any well-authenticated reference to the cereal in Europe, Asia, or Africa previous to the fifteenth or sixteenth century, leads one to regard the American origin of the plant as a fact beyond dispute. Once introduced into the Old World, however, maize very rapidly became known to the inhabitants of all countries where the climatic conditions allowed of its cultivation, and the cereal received a variety of names. To the British people it is most familiarly known as maize or Indian corn; to the American, merely as corn; in Holland and Hungary it is called Turkish wheat; in central France, Spanish corn; in Turkey, Egyptian corn; in Egypt, Syrian dhurra; and in the South African colonies, mealies. The widespread cultivation of the plant is a convincing proof of its value as a food-stuff, but it is only in a few countries that the cultivation of maize can be regarded as an industry of first-class importance. In Europe the principal maize-growing countries are Hungary, Italy, Spain, and the South of France. In Italy maize is a most important food of the people; everyone eats his daily portion of "polenta," a kind of porridge prepared from the coarsely ground grains, the poorer classes



BREAKING UP THE SOIL WITH THE HELP OF BUFFALOES

being content with a very coarse cereal, while the well-to-do prefer to have a finely ground meal from which the indigestible fragments of the husk have been removed by careful sifting. Maize, indeed, is a most valuable food for both man and beast. It is said to be more nutritious than most other cereals, including wheat, and, with the outer husk removed, it is easily digestible. The germ of the grain, however, contains an oil which imparts a peculiar and somewhat disagreeable odour to the meal, a fact which militates against the extensive use of the grain for human food. As a food-stuff for all kinds of farm stock, especially cattle, pigs, and poultry, maize is of the greatest importance, and is one of the most extensively used grains of the world. Although very rich in nitrogenous matter and fat, it is not suitable for making bread unless mixed with about twenty-five per cent. of wheat or rye flour. A bread prepared from the latter mixture was formerly largely



REAPING MAIZE IN ITALY

used in the Atlantic States of America. The maize bread sold in the streets of Constantinople is also a mixture of maize meal and wheaten flour, but the proportion of the wheat is generally insufficient to render the bread palatable to Western people.

Maize starch or corn flour is largely used as a substitute for arrowroot and for making biscuits, and inferior qualities are employed for laundry purposes. It is prepared by crushing the soaked grain and allowing the starch to settle from the starch-milk upon inclined tables. The gluten may be removed by apt treatment with alkaline solutions.

The Indians of Yucatan use the meal for making cakes known as "tortilla," which are said to be very nutritious, and in many parts of the world the young unripe cobs, which are very sweet, are boiled and form a favourite vegetable.

Among other uses to which maize is put must be mentioned the utilisation of the dried leaves and stems as a material for the manufacture of coarse paper. The germ of the seed also contains a valuable oil known as maize-oil, which is largely used in the United States as

a table oil and for making soap. It was formerly obtained as a by-product in the alcohol distilleries, where maize is largely used as a source of spirit, but is now obtained on a large scale from the isolated germs by hydraulic pressure.

The inner leaves which enwrap the cobs are used by the natives of the Sunda Islands for making cigarette papers. The leaves are boiled for a few hours in a solution of sugar, and then, after being smoothed out and dried, are ready for use. The "papers" are said to improve the flavour of the tobacco in these cigarettes, which are very popular among the people, being sold in packets of ten for a few cents.

In addition to the countries mentioned above, maize is cultivated very largely by the natives of Africa as a food-stuff for themselves and their cattle, and also by the colonists. In the East it is also largely grown, but the two principal maize-producing countries of the world, which export the cereal in enormous quantities, are the United States and Argentina.



KAFFIR WOMEN GRINDING MAIZE

Maize is an annual grass reaching, under average conditions of soil and climate, a height of from six to eight feet. The stem is not hollow, as is so commonly the case in members of the grass family, but is solid, and in its younger stages contains a considerable proportion of sugar, a fact which renders the plant of considerable value for forage.

The leaves vary greatly in length, but generally have an undulating margin, and their colour may be green, yellow, or red, according to the variety of the plant. They are generally covered with a fine down on their under surface. Variegated and other varieties are frequently grown in the open air in summer in parks and gardens in this country for the sake of their foliage.

The male flowers are borne on the top of the stem in the so-called "tassel," and form large quantities of loose dry pollen, which is readily scattered by the wind. The female flowers, on the other hand, are protected by the bases of the foliage leaves, and occur on spikes which are further protected by the strong sheathing "spathe." From the apex of the female spike, or cob, as it is termed, the delicate styles of the flowers hang out in the form of a dense silky plume, and sooner or later the male pollen floating in the air comes into contact with these when fertilisation is effected, and we have the delicate spike developing into the ripe golden-yellow maize-cob, so well known to everyone.

Maize, however, is an extremely variable plant, and it is said that over 300 recognisable varieties are known. Some are only a few inches in height, while others are giants of several feet; some come to maturity in two months, while others require three or four times as long before their cobs ripen. There is also great variety in the shape, size, and colour of the actual



PORTUGAL. STRIPPING THE COBS WITH THRESHING FLAILS



MEASURE USED IN INDIA FOR MAIZE

grain or corn. Some are white as, for example, the Cuzco maize, others are yellow, red, purple, or even striped, and the varieties differ among themselves in chemical composition.

As stated above, the most important maize-growing country of the world is the United States, where, incredible as it may seem, maize is the most valuable crop, surpassing even cotton. Many varieties are cultivated, but the chief may be roughly grouped into four classes. First come the "Flint" varieties, which are most commonly met with east of Lake Erie and north of Maryland, and the "Dent" varieties are most popular west and south of these localities. The "Horse-tooth," which passes insensibly into the above forms, is grown chiefly in the south, and, lastly, the "Sweet" varieties are extensively cultivated for the green cobs, which are boiled and used as a vegetable, and seldom allowed to mature into the ripened grain.

The State of Kansas is one of the principal maize-growing districts of America, and enormous quantities of the grain are here annually produced. The country, which is generally flat, is intersected by many rivers, tributaries of the Mississippi, a fact which has a two-fold bearing upon the agriculture of the district, for it allows of a fertile, well-watered, alluvial soil, and places cheap means of transport in the hands of the farmers. The seed is generally sown at the beginning of May, and the experience of most farmers is that the sooner the seed can be put into the ground the better will be the crop. The soil is previously well prepared with the



REAPING MACHINE CUTTING OFF STEMS AND BINDING THEM INTO SHEAVES



A GOOD MAIZE YEAR

plough and the harrow, and the seed carefully sown in rows by means of a "planter" drawn by two or more horses. The seed is sown at a depth of from one to four inches, according to the soil, and automatically covered again with the earth as the machine passes along. The actual distance between the rows and between the individual plants in the rows has been the subject of much experiment in America, and it has been found that the distances must be varied according to locality and circumstances. In an average case the rows are placed about



PACKING MAIZE IN BAGS FOR EXPORT

three feet six inches apart with a distance of two feet between the plants. The essential points are to obtain an even distribution of the plants, and to avoid the extremes of overcrowding and planting at too great intervals. Great care is taken in the proper cultivation of the field during the early stages of the young plants, and the most successful corn growers are those who realise the importance of removing the weeds as completely as possible, and breaking up the soil as soon as it becomes caked; none of the cultivation is carried out by hand, horse-machinery being employed in all cases.

As soon as the grain has ripened, the crop is harvested and the cobs removed for threshing or "shelling." In the tropics and Southern Europe these processes are generally carried out by hand, but in a country like America, where labour is expensive, this is impossible, and necessity has resulted in the invention of the most ingenious machinery which performs the operations in a most efficient manner.

. . . . . .

During its growth maize has but few enemies, either fungal or insect. This desirable state of affairs is no doubt largely due to the fact that the external cuticle or skin of practically the whole plant is relatively tough and impenetrable, and therefore fungal spores are unable to penetrate into the tissues of the plant, and insects probably find it equally difficult to pierce the skin and to deposit their eggs. Maize is not without its enemies, however, but they are most dangerous when the grain is stored on board ship for export. Several beetles and the maize-fly, known in South America as "palomita," then commence their ravages, which are in some cases kept in check by exposing the grain to fumes which stifle the insects. One of the best preventatives against these pests, however, is to arrange for the shipment of the grain before the full heat of the summer, for a high temperature is one of the most powerful factors in the rapid development and increase of these insects.

The rapid increase in the exports of maize from the Argentine during the last few years has been most remarkable, and at the present time it is estimated that there are nearly 5,000,000 acres under cultivation for this cereal. There can be little doubt that in a comparatively short time this wonderful country will oust the United States from its premier position, and become the chief maize-growing country of the world. The principal provinces concerned with the crop are Buenos Aires, Santa Fé, Cordoba, and Entre Rios, especially the two first named, and while hitherto maize has been chiefly raised as an accessory crop, many landowners are adopting it as their staple cultivation. The importance of the cereal to the Argentine is two-fold; in the first place, a valuable export trade is already established, and, secondly, the grain is every year being more largely used as a food for the cattle and stock which form so important a part of the wealth of the country. The land is largely worked by poor and ignorant immigrants from Europe, chiefly Italians. As might be expected, the methods of cultivation employed by these people have, up to the present, been extremely primitive and unscientific, and the results achieved are due to the marvellous fertility of the soil and the perfect climatic conditions. Nevertheless, it is only right to say that the methods are improving year by year, and that the leaven of modern ideas is penetrating into the minds of the colonists, and the Argentine affords a very large market for up-to-date machinery.

At the present time considerably more than one-half of the total crop is exported, and one

of the chief difficulties of the industry is the efficient shipment of the grain. Until quite recently the facilities for handling the grain in Argentina were very inadequate, but [illegible] freight cars are now being used on the railways in place of the older cars of English t[illegible] which had a capacity of not more than fifteen tons. Further, the authorities of the great shipping ports, Buenos Aires, Rosario, Bahia Blanca, and La Plata are making improvements in the docks and general shipping facilities, and there can be no doubt that the effect on the export trade will be most marked.

One of the greatest difficulties with which the shipper of corn from the Argentine has to contend is the question of the dryness of the grain, and this vital quality is harder to obtain than any other. It has been stated that fully three-fourths of the losses on Argentine corn going to Europe have hitherto been due to the dampness of the grain before it left the River Plate, with the result that on arrival in Europe the grain is found to be heated and fermented. The shipper has constantly to be on his guard against receiving damp grain, and when once shipped dry his great anxiety is to get it out of the River Plate before the cargo has absorbed much of the humidity that prevails there during the greater part of the shipping season. Until comparatively recently it was held [illegible] and even [illegible] to ventilate the cargo on the voyage, but the general opinion among [illegible] shippers now is that this is unnecessary and in all probability does [illegible] only a comparatively small



PERSIA. A MAIZE BARN

portion of the grain comes in contact with the air, which itself is generally damp. If the ship sails within fifteen or twenty days after she has begun to load, and the cargo is of dry grain, stowed in dry weather, no damage will be done, so long as the hatches are securely battened down, and as nearly as possible hermetically sealed during the whole of the voyage. The dampness of the grain is largely due to the shipping being carried out in wet weather, but in the opinion of one of the leading exporters the chief cause is the bad system of cultivation largely adopted in many parts of the country. One of the worst mistakes of the farmers is to plant more of the crop than they can possibly harvest to advantage, with the result that large quantities of unripe cobs are shelled, and in order to gather in the huge crops the harvesting has to be carried out in all weathers, wet or fine.

At the present day one of the most important and interesting lines of work which is being carried on by the scientific agriculturist is the improvement of field crops by selection and by the breeding of new varieties. Such work has been largely carried out in the case of maize, especially in the United States, and already the most notable results have been achieved. Briefly put, the principles underlying the whole of the work are that we may "improve" an existing plant, especially if it happens to be a variable plant of which there are many varieties, by selecting for seed purposes only those fruits which in themselves possess desirable characters, or are borne on plants which possess such characters. For example, if maize is grown for the grain, only those corns should be sown which have been selected for their size, colour, high proportion of nutritive matter, early ripening qualities, etc., while if the maize is grown for fodder, seed should be taken from plants which possess an abundant leaf surface of known value as an animal food.

The breeding of new varieties is a more complex question, demanding in some instances considerable scientific knowledge and practical skill, but the essential features of the operations are that by ensuring the fertilisation of a female plant, possessing characters of recognised value to the farmer, by the pollen of a male plant also possessing the same, or it may be different but equally valuable, characters, it is possible to accentuate the characters as it were in the offspring, or to combine them. Experiments are, therefore, being carried out at the present time having for their object the production of new varieties of maize possessing desirable qualities. Thus, one line of work lies in the production of a maize which shall yield a much larger crop per acre than the varieties commonly grown; another line aims at a grain of improved nutritive value, and another is concerned with producing a grain which shall contain a larger proportion of oil in the germ, so that it may be of more value to people interested in the manufacture of maize oil.



GRINDING MAIZE

MILLETS



STRIPPING THE COBS IN NAPLES

THE term "millet" is employed to include a large number of cereal and forage grasses, the seeds of which are usually smaller when compared with other cereals such as wheat, barley, and oats. The importance of the millets as a source of human food is by no means fully appreciated in this country, no doubt on account of the comparatively trifling part which they play in our domestic economy. It has been estimated, however, that fully one-third of the world's inhabitants employ millet as a regular article of food; in India there are nearly 40,000,000 acres devoted to the crop, and Japan alone consumes annually 35,000,000 bushels of the seed. China and Korea use enormous quantities, and the important part played by the grain in the late Russo-Japanese War will be fresh in the mind of the reader. Further, in nearly all parts of the world millets take a prominent place as a source of forage.

ITALIAN AND HUNGARIAN MILLET

Probably the most important millet cultivated by man is the Italian millet (*Setaria italica*), and its variety the Hungarian millet (*S. italica* var. *germanica*). There is considerable difference of opinion as to the original home of this species, but the view advanced by some writers that the plant is native to Southern Europe does not seem to be supported by sufficiently good evidence. Writers on Chinese economic plants include this variety of millet in the five plants sown each year by the Emperor in accordance with the command given by Chin-nong in B.C. 2700. Now each of the five plants is regarded by the Chinese as being an undoubted native of their country, and this, taken in conjunction with the fact that the species appears to occur in the wild state in Japan, led De Candolle to the belief that *S. italica* existed thousands of years ago before all cultivation in China, Japan, and the Indian Archipelago. Its cultivation probably extended very rapidly westwards, for the seed has been discovered among the remains of the lake-dwellers of the Stone Age in Switzerland. The grain apparently was unknown in ancient Syria, Arabia, and Greece, and it reached Switzerland probably *viâ* Russia and Austria.

Italian millet is more or less extensively grown throughout temperate Europe, a large part of India, China, Japan, Northern Africa, the United States, and Canada. With the exception of America, where it is grown almost exclusively for forage, this cereal is raised for human food, and is also employed to a relatively very small extent as a bird seed. The abundance of the grain found in the Lake dwellings clearly indicates its importance as a food in prehistoric times, and there are historical records of similar uses in China nearly 3,000 years before the Christian era. At the present day it is chiefly used in Japan, China, and India, where it is also largely grown for forage. The grain is usually prepared by boiling or parching, and may be eaten alone or mixed with milk and sugar.



THRESHING MAIZE COBS

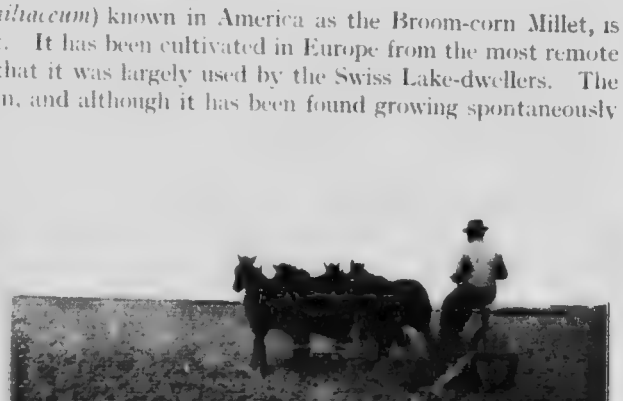
BARNYARD MILLETS

Another important group of millets are those belonging to the genus *Panicum*, and known in the United States as the Barnyard Millets. The plants vary considerably in habit, but are typically coarse-growing, with widely spreading stems bearing broad leaves and large irregular "heads" of flowers and seeds.

The true barnyard millet, *Panicum crus-galli*, occurs rarely as a wild plant in this country, but is grown extensively in many parts of the world, chiefly in the Far East and India, in the latter country being known as "Bharti," and used for forage and as a food-stuff by the poorer natives. Other important Indian millets are "Shama" and "Sanwa"; the former (*Panicum colonum*) is a much smaller plant than *P. crus-galli*, but is one of the most valuable forage crops of the East Indies, where it is also used for human food. The food value of the grain is not considered by Professor Church to be very high, but in certain districts it is used fairly extensively by labourers, and it is also said to be eaten on fast days by Hindoos, who, by boiling the grain in milk, produce a preparation known as "Khir." The Indians of Mexico and the south-western United States are also said to eat this millet. "Sanna" millet is a coarse-growing plant with a large amount of herbage, and is the most rapid grower of all the millets. Its nutritive value is not high, but in India it is either prepared as rice, or boiled with milk, or eaten merely parched. In Japan this variety is largely cultivated in those districts where, owing to the hilly nature of the country or to the absence of water for irrigation purposes, it is impossible to grow rice. It is grown entirely as a human food, the grains being ground and the meal eaten as a kind of porridge.

COMMON MILLET

The Common Millet (*Panicum miliaceum*) known in America as the Broom-corn Millet, is generally regarded as the true millet. It has been cultivated in Europe from the most remote times, and there is direct evidence that it was largely used by the Swiss Lake-dwellers. The origin of this millet is very uncertain, and although it has been found growing spontaneously in Southern Europe and in many parts of Asia and Africa, there is no authentic instance of its having been found truly wild. The botanist Linnæus regarded India as the home of the plant, but De Candolle does not consider the evidence as perfectly satisfactory, and is inclined to think that an "Egypto-Arabian origin is very probable." Common Millet is extensively grown in the Mediterranean region, in Russia, China, and Japan. It



SOUTH AFRICA. MECHANICAL SOWING OF MAIZE

was introduced into America many years ago, but, except in the north-western States, it has not met with much favour. There are three principal varieties cultivated, readily distinguishable by the colour of the seeds, which are white, yellow, and red. The white-seeded form appears to be the most robust plant, and the yellow-seeded varieties have usually their foliage of a much lighter green colour than the red-seeded plants, whose leaves are distinctly tinged with red.



BINDING THE STEMS INTO SHEAVES

GUINEA CORN, SORGHUM, OR DHURRA

Guinea Corn or Sorghum (*Andropogon Sorghum*) is a very extensively cultivated cereal, and which is known under a bewildering variety of names. It is generally regarded as a native of South Africa, where it is known as Kaffir Corn, taking its name from the native tribe of that name; northwards, in the Sudan and Egypt and in other parts of Africa it receives the name of "Dhurra," and it is also variously described as "Millet," "Guinea Corn," and under other names. It should not be confused with "Guinea Grass" (*Panicum maximum*), a valuable fodder grass native to West Africa, but now extensively cultivated almost throughout the tropics.

A lamentable confusion exists in the botanical nomenclature of the Sorghums as a class, but it seems possible to reduce them to three



TILLING THE SOIL



A SMALL FARM IN SOUTH AMERICA

main divisions, which may be stated as follows: *Andropogon Sorghum* var. *vulgaris*, yielding the innumerable varieties of Kaffir Corn, dhurra, etc.; *A. Sorghum* var. *saccharatus*, the sugar sorghum, known in the West Indies as "Imphe," and used for fodder, also a source of sugar; and *A. Sorghum* var. *technicus*, the fruit-stalks of which, when the grain is removed, are used for making brooms and brushes. A description of this latter plant and its uses will be found in the section dealing with "Fibres."

As stated above, *Andropogon Sorghum* var. *vulgaris* possesses a great number of varieties, which are cultivated as a food crop in practically all the warmer countries of the world. They may, however, be reduced to three principal forms, viz.: (1) *Red Kaffir corn*, a plant from five to six feet high, bearing thick, somewhat rough, leaves, and a long, narrow, erect head of light brown or red seeds so closely packed together as to hide the stems bearing them; (2) *White Kaffir Corn*, similar in habit to the last, but smaller, and bearing a slender compact head of whitish seeds; (3) *African Millet*, with a habit similar to that of the White variety, and also with white seeds, which, however, are often spotted, and the chaff of the seeds is grey or black. Sorghum is very largely used for human food in India, Africa, and China, and its importance as a fodder for cattle in these countries is very great. When employed as a fodder, however, it has been repeatedly noticed that the stock sometimes sicken and die as a result of what is known as "sorghum poisoning," and recent investigations carried out at the Imperial Institute at South Kensington have afforded an explanation of these observed facts. It appears that while the plant is comparatively young, the active poison prussic acid is developed by the interaction of two complex chemical bodies contained in its tissues, and that when the sorghum becomes mature the poison is no longer formed. The practical value of this observation is at once evident, since by feeding only mature sorghum to stock it is possible to avoid all risk of poisoning.

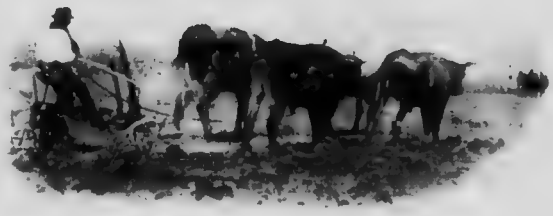


IN THE LARGE FIELDS OF KANSAS

KORAKAN OR RAGI

In India and Japan and some other countries an important food-stuff is yielded by *Eleusine Coracana*, a tall annual grass with tufted stems each bearing from four to six spikes of flowers. A fact which adds greatly to the value of the plant is that it yields an abundant crop even when grown on poor soil. Korakan is cultivated over the greater part of India, largely during the rainy season, and is an important food of the poorer classes. It is said to be peculiarly free from attacks by insects, and can therefore be stored a considerable time without damage, a point of especial advantage in tropical countries.

The grain is not generally considered to be very wholesome as it is somewhat difficult of digestion, but it is extensively eaten, and in Mysore the flour is used for puddings or made into cakes which are fried in oil; in other parts of India a fermented liquor is prepared from the grain.



BREAKING CLODS OF EARTH WITH POWERFUL HARROWS

PEARL MILLET

Pearl Millet, also known as the Spiked or Bullrush Millet, is a grass (*Pennisetum typhoideum*) which grows to a height of five or six feet, and bears compact cylindrical spikes of grain about twelve inches long. It is largely cultivated in India, and is also grown in Egypt and other parts of tropical Africa, which country is probably the true home of the plant. In India *Pennisetum* is extensively cultivated in the Bombay Presidency, and, like *Eleusine*, is a rainy season crop. It forms an important food of the lower classes of natives, and on account of its heating qualities, is largely consumed by the tribes of Northern India during the cold weather. The flour prepared from the millet is made into cakes and bread, which are considered to be very nutritious, and in some districts the grain is used by the well-to-do.

JOB'S TEARS

Job's Tears are the fruits of *Coix lachryma*, a grass native to India and Japan, but now found in many tropical countries. The comparatively large, shining, pear-shaped fruits, which bear a fanciful resemblance to immense tears, are used as food in some of the poorer districts of India and Japan, and in China are accredited with medicinal properties.



TILLING VIRGIN SOIL

The "tears," however, are principally used for ornamental purposes, lending themselves especially for making necklaces and mats. Samples of such articles made in the West Indies are nowadays not unfamiliar in some of the London shops.

BUCKWHEAT

Compared with many other food grains, buckwheat is of comparatively recent cultivation, for the earliest record of it occurs in Chinese writings relating to tenth and eleventh centuries. The plant (*Fagopyrum esculentum*) is a branching annual about two or three feet high, and is a native of Central Asia, having been found wild in Manchuria, on the banks of the Amar, and in the neighbourhood of Lake Baikal. According to De Candolle, one grain was introduced into Europe during the Middle Ages through Tartary and Russia, and the first mention of its cultivation is found



HARROWING



CHINAMEN THRESHING MILLET

in a German register dated 1436. At the present time it is largely cultivated in many parts of the world, especially in Russia, France, and other parts of the Continent, and also in the United States of America. In England very little buckwheat is grown. Some varieties of buckwheat grow in Russia in the dry and arid districts, to which reference has already been made (pp. 14 to 16), where the hard or macaroni wheats are extensively cultivated. For buckwheat the ground is ploughed in the autumn and again in the spring, when it is also harrowed. Sowing takes place quite late, in order to avoid any danger from the frost. In some districts, for instance, the seed is not put down until the beginning or even the end of June, and the crop is harvested from about the middle of August to early in September.

Buckwheat has a particular interest inasmuch as, although it is popularly termed a "wheat," it is not a wheat nor even a cereal at all. The plant is a member of the natural order *Polygonaceæ*, and is closely allied to the common knot-grass, and the docks so abundant as weeds. The fruits of the plants of the order are characteristically small three-cornered "nuts," and the scientific name, *Fagopyrum*, recalls the resemblance of the buckwheat fruits to beech nuts. Inside the thin brown covering of the little "nut" is the white floury substance, for the sake of which the plant is so extensively cultivated.



NEAR PEKIN. A MILLET FIELD WITH AN ADJACENT SORGHUM FIELD

The nutritive value of buckwheat is low in comparison with wheat, but is yet sufficiently high to render it of importance as an article of food in several parts of the world. For instance, in Russia buckwheat plays its part, along with the millets of various kinds, in contributing to the dietary of the peasants, and in some districts these grains constitute the principal means of subsistence. The total area under buckwheat in Russia is estimated at close upon 5,000,000 acres. The Russians denote all these various food-stuffs, when in the raw state, as "krupa," this word corresponding practically to groats. Buckwheat groats, "grechevnaya krupa," are a popular food, and are prepared very simply by hulling the little nut-fruits or "grain" of the plant, and grinding the contents. These buckwheat groats are boiled and converted into porridge, but more commonly are made up into various types of compact cakes and served with soups, and in other ways.

In the United States some 800,000 acres are annually cultivated with buckwheat, the estimated value of the crop, 14,000,000 bushels, being about £1,700,000. Buckwheat cakes are well known as one of the special dishes of the States.



MAIZE

STARCHES

STARCH is prepared by plants in their leaves and other green parts from water and the carbonic acid gas of the atmosphere, under conditions of sufficient warmth and sunlight. The excess of starch made above immediate requirements is stored up for the future use of the same plant, or in seeds, tubers, etc., to give a good start in life to the succeeding generation. Man takes advantage of this storing habit, and appropriates the supplies for his own use in several instances. Starch belongs to the large group of substances known as carbohydrates, and is very similar in chemical composition to sugar. Plants store up starch in the form of small grains or granules, which vary very considerably in size, shape, and other characteristics in different plants, so that it is easily possible, with the help of a microscope, to ascertain the source of a sample of starch, and whether it is pure or adulterated. An admixture of cheap forms of starch in expensive arrowroots can in this way be detected with the greatest ease.



MAIZE GROWN AS A CATCH CROP IN BARBADOS

POTATO STARCH

By far the greater part of the starch used for commercial and technical purposes is obtained from potatoes. Enormous quantities of the tubers are raised on the Continent and in the United States, and, besides being employed as an article of food, are used as a source of alcohol and starch.

The potato contains starch to the extent of fifteen to twenty-five per cent. according to soil, climate, and manuring, and about sixty-six to seventy-five per cent. of the full amount is obtained by the manufacturer. The starch is contained in the cells of the tuber as oval grains, and the processes of the manufacture aim at obtaining the grains in a perfectly clean condition, free from all particles of cellulose and vegetable matter. The methods adopted vary somewhat in different countries, but the essential features are the same in all cases, and the processes of manufacture are relatively of great simplicity. A full account of the industry in the United States has recently been published by the U.S.A. Department of Agriculture, and the following information has been summarised from this report. The principal states concerned in the industry are Maine, New Hampshire, New York, and Wisconsin. The first process consists in washing the potatoes, and is carried out in revolving cylindrical washers about twelve feet long and two feet in diameter, through which water is constantly passing. The potatoes when perfectly clean are submitted to the action of a cylindrical rasper turning at the rate of over 600 revolutions per minute, and a stream of water passing through the machine carries the starch pulp away as soon as it is reduced to the required degree of fineness. The pulp falls from the rasper into a fine wire gauze "starch separator," the meshes of which are sufficiently large to retain the vegetable *débris* but allow the starch grains to pass through. The actual passage of the grains through the separator is effected by shaking the framework in a sloping position and allowing jets of water to play upon the starchy mass. The starch which is carried through by the water falls into tanks placed underneath the separators, and

quickly settles to the bottom when the supernatant water is drawn off. It is again beaten into a cream with water by mechanical stirrers, and when it has once more settled and the water has been removed, it is found that the upper layers are somewhat discoloured, while the main mass of the starch below is of a pure white colour. The pure starch is ready for the drying tables while the discoloured layers are further cleaned by repeated processes of stirring and allowing to settle.

In the more modern factories the drying is performed in kilns provided with steam heaters. It is important that the wet starch should not be subjected to the full force of the heat at once, or the grains would be converted into paste and rendered unfit for the market. The kilns are, therefore, built with four or five floors made of narrow wooden slats fixed a short distance apart, and the steam pipes are laid at the bottom of the kiln. The blocks of wet starch are



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YOUNG CULTIVATION, WITH CATCH CROP OF BANANAS, CASSAVA, AND TANIA, TRINIDAD

shovelled on to the uppermost floor, which is the coolest part of the kiln, and the drying commences. After a little while the mass is raked over, and the drier portions of the starch automatically fall between the slats on to the next floor below, where they are subjected to a higher temperature. The process is repeated on each floor until the whole of the starch has reached the bottom of the kiln, which is filled and emptied twice in every twenty-four hours. The dried starch is finally raked into a trough and transported to warehouses where it is stored on the floors, the piles resembling huge snowdrifts. During this storage the starch becomes uniformly dry, and is finally packed in barrels.

Potato starch is very largely employed in the textile industries, where it is used for three distinct purposes: in the first place, it is used as a sizing for the warp yarn before it is woven the loose ends of the fibres composing the yarn being cemented down, resulting in a smooth strong thread; secondly, the starch paste is used to give a finish to the goods after they have been woven; and, thirdly, in the form of dextrin, potato starch is used to a certain extent as a thickener or vehicle for applying colours to the fabric.

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THE BREAD-FRUIT

Large quantities of dextrin or British gum are manufactured in Europe from potato starch. The starch is subjected to a high temperature, preferably in contact with the diluted vapours of nitric acid.

CASSAVA STARCH AND TAPIOCA

Cassava, manioc, or mandiocca, is the starch prepared from the roots of two species of *Manihot*. The plants, which are natives of tropical America, are very closely related, and are often regarded merely as varieties, and not as separate species. They are shrubs reaching a height of about six or eight feet with repeatedly forking branches, bearing palmate leaves divided into from three to eleven divisions, and mounted upon slender leaf stalks. The roots, which are the only valuable portions of the plant, grow in clusters often weighing as much as twenty pounds or more: the individual roots vary in length from one-and-a-half to four or even six feet, and generally average about two inches in diameter.

Cassava is extensively cultivated in many parts of the tropics, since it is a crop which yields a large return for a comparatively small amount of labour; large quantities are grown in Brazil, Guiana, the West Indies, West Africa, the East Indies, and the Straits Settlements.

Both the "Sweet" and the "Bitter" Cassava are extensively grown, but the "bitter" is more generally cultivated, as, although it requires a much longer time to reach maturity, it produces a greater yield of roots. There are a dozen or more varieties of the bitter cassava grown in Brazil differing principally in the colour of the stems and roots and in time of reaching maturity. All of these varieties contain a considerable amount of the active poison prussic acid, but fortunately the poison is very volatile and is entirely dissipated by moderate heating, so that, after proper cooking, there is no danger of poisoning when eating the roots or the starch prepared from them.

In his interesting book, "Among the Indians of Guiana," Sir E. F. im Thurn gives a detailed account of the methods of preparing cassava adopted by the natives, who make the product into bread resembling oatcakes or use it as a kind of meal. The operations are principally carried out by the women, and form a characteristic feature of Indian life. The women squat upon the ground and peel the outer rind from the cassava roots with a large knife. Each root after being peeled is thoroughly washed, when it is taken in hand by another woman, who scrapes it vigorously up and down a rasper consisting of a short board studded with small fragments of stone. One end of the rasper stands in a trough on the ground and the other rests upon the woman's knees, and, as the pulp slips from the scraper into the trough it is collected and put into a long narrow cylindrical bag which hangs from the roof of the hut. The bag, which is known as a "matapie," is woven from strips of the pliant cuticle of the leaves of the Ita palm, and its use is to squeeze the poisonous juice out of the cassava. This is effected in one of two ways; a common practice is to suspend a heavy weight from the lower end of the tightly packed matapie which, as stated above, hangs from the roof, and the



A "FALSE SAGO" PALM

resulting pressure is sufficient to squeeze out the poisonous juice through the sides of the bag. In other parts of the country a heavy lever is placed through a loop at the end of the matapie and one end fixed to the floor, while upon the other end the woman seats herself so that her weight exerts a powerful leverage on the bag, which is drawn taut, causing the juice to be expressed as before. The cassava, freed from the liquor, contains but little poison, and this is entirely dissipated in the subsequent process of cooking. The meal is taken from the matapie, broken over a sieve, and then sifted until it is converted into a coarse flour. The latter is then either packed in leaves for future use, or at once made into bread or into the thin circular "cassava cakes" which are well known wherever cassava is cultivated.

The poisonous juice expressed from the cassava pulp is not wasted; for it is the source of "cassareep," which is well known as an essential ingredient of the West Indian dish, "pepper-pot." Cassareep is prepared by boiling the juice until it becomes of a thick, treacle-like consistency, when it is no longer poisonous. It is largely used in this country as a basis for sauces.



THE SOURSOP
(*The unripe fruits yield starch*)

The popular starchy foodstuff "tapioca" is prepared from cassava, and is largely imported into England from Brazil and the Straits Settlements. Its method of preparation is comparatively simple, but in the countries mentioned, where the product is a valuable article of export, the cassava is prepared on more practical lines than that described above. The roots are ready for digging in about from six to twelve months, when they are grated on a machine. There are two methods of preparing the starch: in the "wet" method the grated root is placed in water for a few days, when it is kneaded with water, and finally pressed to extract the juice. The resulting fecula is sifted and baked in earthen ovens. In the "dry" process the grated roots are mixed with water without any previous soaking and subjected to pressure. After drying and sifting, the fecula is washed several times and finally dried in the sun. The cassava is now ready to be made into tapioca, and the process consists merely in heating the starch on flat iron plates, when it becomes partially cooked, and agglomerates into the hard, small, irregular lumps which are so familia

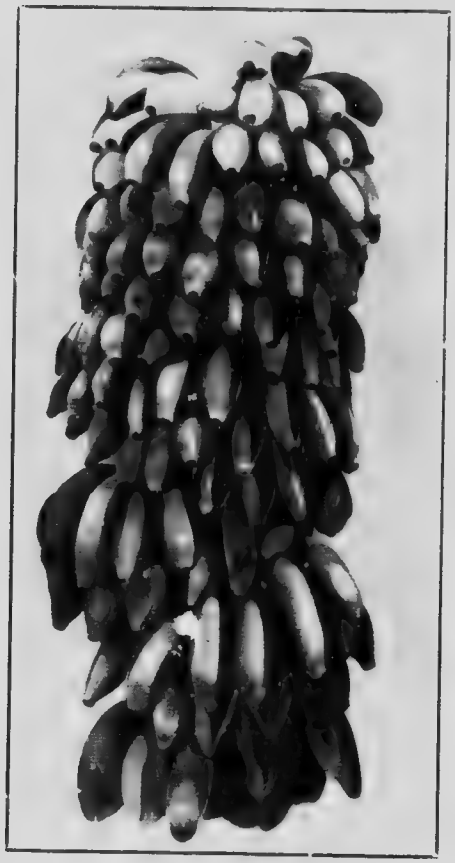


PLATE V. F. Isaacs, Southampton

BREAD-FRUIT TREE

RICE STARCH

The grains of the rice plant, which is grown in enormous quantities in irrigated fields in tropical and sub-tropical countries, (see special article on "Rice"), are very rich in starch, containing over seventy-five per cent. of the material. It is one of the principal sources of laundry starch. In this case, soaking the grain and afterwards subjecting it to a bruising process is not sufficient to separate the starch, and the rice is therefore previously treated with a weak solution of caustic soda, which softens the grain and causes it to swell. It is then washed with clean water, and subsequently ground between millstones and brushed through sieves to remove foreign particles. The fine rice flour is again treated with the alkaline solution, in which it is vigorously agitated for some twenty-four hours. It is allowed to settle, when the supernatant liquid containing the gluten in solution is drawn off, and the starch collected and washed in water. It is allowed to settle and is finally dried.



BANANAS

An acid process is also employed in the manufacture of rice starch. The grain is soaked and ground between rollers, and treated with a dilute solution of muriatic or hydrochloric acid, which dissolves away the non-starchy constituents, leaving the starch only to settle in the tanks.

WHEAT STARCH

Wheat Starch is largely used in the textile industries as a thickener for applying dyes to the fabric. Three principal methods have been employed for obtaining the starch, which exists in the grain to the extent of from fifty to seventy-five per cent. In one method the starch is obtained from the flour, which is kneaded into a stiff dough with water, and after a short period, about one or two hours, washed in a sieve with water until all the starch has escaped through the meshes as a milky fluid. The starch is allowed to settle in tanks and after being purified by several washings, is ready for drying and packing. This process possesses an advantage over the next, inasmuch as the gluten of the dough is not destroyed but is available for commercial purposes. In the second process this is not the case, for the starch is obtained by allowing the wheat to ferment, resulting in the destruction of the gluten. The grain is first soaked in water for a few days, the period being longer in winter than in summer, and then the foul water is drawn off and clean supplies admitted. The grain is crushed between rollers and allowed to ferment for about a fortnight, the process involving the destruction of the gluten and the liberation of the starch grains. The starchy mass is afterwards transferred to a revolving drum through the perforations of which the starch escapes, as a result of continual stirring, into tanks placed underneath. The purification of the starch is effected by repeated washings with pure water.

COCOA-NUT PALMS



Photo by Sir Harry Johnston, K.C.M.G., K.C.B. By permission of Messrs. Hutchinson

BORASSUS PALMS

In the third process the starch is obtained without any fermentation taking place, the grains being merely soaked and bruised, and afterwards washed repeatedly.

MAIZE STARCH

Maize Starch, familiarly known as "corn flour," exists in the grain to the extent of about fifty-four per cent., and is obtained by various methods, which are, however, very similar. The washed grains are passed between rollers or millstones and ground to a paste, which is washed in perforated cylinders resembling those employed in the manufacture of potato starch. The starch milk is allowed to run upon inclined tables, where the grains are deposited, while the nitrogenous matters pass on and are collected in tanks to be subsequently used as cattle food.

Maize starch is largely used as a paste for finishing textiles, especially in America. The finer qualities are employed as a substitute for arrowroot, while the inferior grades serve for laundry purposes.

ARROWROOT

Arrowroot, or West Indian arrowroot, as it is sometimes termed, to distinguish it from other kinds, is obtained from the underground stem. of *Maranta arundinacea*, closely allied to the Ginger and Turmeric plan The plant occurs in many parts of the tropics, but Bermuda and St. Vincent are the chief places of arrowroot manufacture. The underground stems are often from one to two feet in length, rather less than an inch across, jointed, and almost pure white in colour. The thin skin which covers them contains bitter principles which would injure

the starch in point of flavour, and in the most careful mode of preparation great care is taken to remove this skin by peeling.

Owing to the great care bestowed on its manufacture and to its wide reputation, Bermuda arrowroot commands very high prices in the market. St. Vincent arrowroot realises very much lower prices: recently, however, an improvement has set in. In Barbados and in other West Indian colonies there is a small amount of arrowroot grown, but it is used locally for laundry and other purposes.

Arrowroot is one of the most easily digested forms of starch, and is in considerable demand for invalids and children.

SAGO

Sago is obtained from the trunks of several species of palms, of which *Metroxylon Rumphii* is one of the most important. The home of these palms is the Far Eastern tropics, and in the Straits Settlements, the Federated Malay States, Java, the Celebes, Borneo, Sumatra, and the adjoining islands sago is one of the important staples of food.

The typical sago palms (*Metroxylon*) live in more or less swampy localities. In common with some other palms they flower only once in their life and then die. The flowering takes place when the plant is about fifteen years old. Immediately, however, before the flowering period the whole trunk of the tree is loaded with starch which the plant has accumulated to be employed in providing the reserve of food in the expected heavy crop of seeds. Man, as usual appropriating the plant's laboriously gathered reserve, fells the tree just before it flowers, and extracts the starch. The root stock does not die, but puts up new shoots or trunks, which are ready to flower in their turn in another fifteen years or so.

Dr. O. Beccari, in his *Wanderings in the Great Forests of Borneo* gives an interesting account of the preparation of sago. The trees are felled when about twenty-five to thirty feet high, and the trunks are stripped of leaves and cut up into sections, each about three feet in length. Each piece is split lengthwise, and the soft fibrous tissue scraped out with a kind of wooden hoe. Successive straining and washing processes serve, as with the other starch-yielding plants, to free the starch granules and to separate them from the tissues of the stem. The latter are removed, and the starch is allowed to settle and finally it is collected and dried. By subsequent treatment the sago flour



Photo by Sir Harry Johnston, K.C.M.G., K.C.B. *By permission of Messrs. Hutchinson*

PALMS—BORASSUS, OIL, AND COCOA-NUT

so obtained is "pearled" and transformed into the small roun masses so familiar in this country.

Some of the Cycads, to which we have already referred under arrow-root, are known as False Sago palms. The illustration on page 69 gives an idea of the habit of this group of plants.

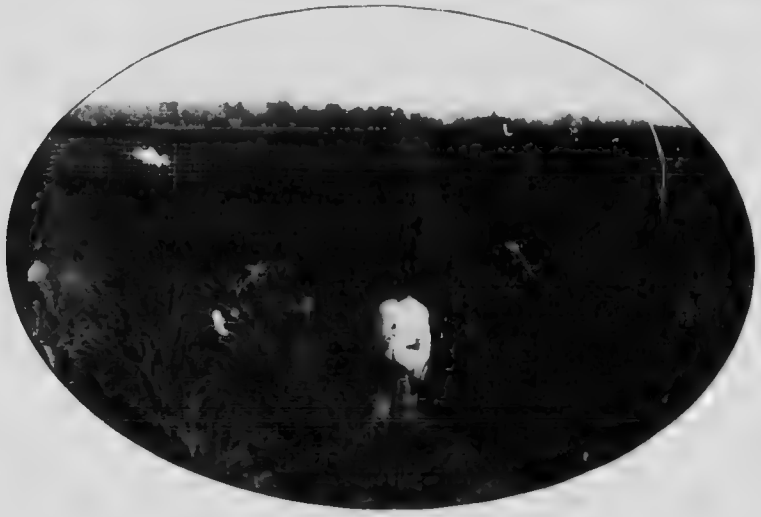
OTHER STARCHES

In addition to the foregoing a considerable number and variety of plants are utilised for the local production of starch. In some parts of the West Indies the unripe fruits of the Soursop, an illustration of a fruiting branch of which is given, are employed to prepare a kind of arrowroot. Another fruit, the mango, is similarly used in the unripe condition. Other examples are the Banana, the Plantain, the cocoa-nut palm, and the Palmyra palm.

The bread-fruit, a handsome tree with large, thick, shining leaves, and fruits of the size of a man's head, yields an excellent starch which can be readily prepared. Samples of bread-fruit starch have recently been received at the Imperial Institute and examined there. The market value of the product in London was about £7 per ton.

SUGAR

SUGAR is one of the most valuable products of the plant world. The quantity which comes into commerce annually at the present time is approximately some 10,000,000 tons, of the value of about £180,000,000, regarding sugar as worth, on an average, about 2d. a pound. This enormous amount by no means, however, represents the total sugar crop of the world, because in India and the East generally, in South America, Africa, and elsewhere, there are large quantities of sugar produced for local consumption which do not figure in commercial statistics. It is impossible also to dissociate sugar and alcohol: rum, arrack, palm-wine, and other spirituous liquors are made in different parts of the world from sugar-producing plants, although rum, produced from the sugar-cane, is the only one which enters the world's markets to any extent. Molasses, or treacle, the uncrystallisable residue remaining after the



JAVA. A FIELD OF YOUNG SUGAR-CANES

MAP OF
THE WORLD
SHOWING
The Sugar Producing
Countries
Steamer Routes
NORTH AMERICA
SOUTH AMERICA
AFRICA
AUSTRALIA
GREENLAND
ARCTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
RUSSIAN EMPIRE
CHINESE EMPIRE



CARRYING CANES TO THE FACTORY IN MEXICO

solid sugar has been obtained, is an important subsidiary product in the cane-sugar industry, and the maple syrup of North America is a delicacy esteemed in countries beyond that in which it is produced. More recently new articles—molascuit and molassine meal—have been added to the list of commercial products of the sugar plants, and altogether this group of plants must be accounted amongst those of the greatest importance to man.

Sugar is very generally distributed in the vegetable world, and almost all plants contain sugar at some stage of their life history. It would be out of place here to enter into a full discussion of the chemical changes which go on in that wonderful laboratory, the green leaf of a plant, but it may be said that in general sugar is one of the first substances manufactured by the plant from the simple materials, water and the carbonic acid gas, of the atmosphere.

The sugar is essential to the life and growth of the plant, and as it can only be formed when the weather is warm enough and in the presence of sunlight, plants manufacture more than they want for their immediate requirements, and literally put the remainder by "for a rainy day." This reserve of food is not always stored away as sugar, but is frequently converted first into starch, and then changed back again to sugar as it is wanted. Plants which store their carbohydrate reserves in the form of starch are the useful cereals, the potato and other starch yielders, already discussed. Some plants, however, actually keep their reserves of food as sugar, and it is with this group that we are immediately concerned. The large roots of the carrot, the parsnip and the beet all contain sugar, accumulated during the first year of the plant's growth, to be drawn upon in the second, when, in the ordinary course of nature, the plants would flower. Although all three are possible sugar-producers, only one, the beet, is made use of by man. The beet is pre-eminently the sugar-yielding plant of the temperate regions, and its cultivation for this purpose is, comparatively speaking, quite a modern enterprise, as we shall describe in detail later. On the other hand, in the tropics there has been grown, from time immemorial, as a source of sugar the famous sugar-cane, a gigantic grass—the thick stems of which contain large quantities of juice rich in sugar.

There are also in the tropics various palms, for example, the date, the Palmyra palm, the coco-nut palm, the sugar palm (*Arenga*), and others, from all of which a sweet juice is obtained

by suitable means and used as a source of sugar. These palms in some countries yield large supplies.

In North America there are the sugar-maples, very closely related to the common sycamore and the field maple of this country, and from them a sugar-yielding sap may be obtained by boring holes in their trunks early in the year. This juice yields the well-known maple sugar and maple syrup so highly esteemed in Canada, the United States, and elsewhere.

A variety of maize or Indian corn, and a kind of Guinea corn or sorghum, are both of local importance as sources of sugar in some parts of the world.

Although the plants mentioned above comprise most of those of value as sources of sugar, there are numerous others which contain sugar, and are potential sugar-producers. Many fruits when ripe are well known to be sweet, and this indicates the presence of sugar. Grapes, for example, are rich in sugar, so also are pineapples and other fruits, but sugar obtained from them would be much too costly to allow of its being used for commercial purposes. The onion also contains a considerable amount of sugar, but is not employed for this purpose on an economic scale.



By permission of the Queensland Government

A SUGAR-CANE FIELD AT VERA CRUZ

Although there is a considerable number of plants which produce sugar in sufficient quantities to render them of importance in the countries in which they are grown, the fact remains that, so far as the commercial production of sugar is concerned, the sugar-cane and the sugar-beet practically have a monopoly. It is true that large quantities of sugar are made from various palms in the East, that sorghum and maize yield their products in America, China and elsewhere, and that the sugar-maples provide a delicacy in the United States and Canada, but none of these plants at present affect the sugar market. Sorghum is sometimes regarded as one of the important sugar plants of the future, but that day has certainly not yet arrived, and beet and cane easily out-distance all competitors. Many people would probably not be prepared to give an opinion offhand as to the relative importance of these two plants, or if they did their estimate might not be very accurate. The total annual commercial sugar crop of the world is now approximately about 10,000,000 tons, and to this enormous quantity the beet contributes about 6,000,000 tons and the sugar-cane some 4,000,000 tons. That is to say, about three-fifths of the sugar of commerce is beet-sugar and two-fifths cane-sugar. If, however, we go back such a comparatively short period as fifty years we find a very different state of affairs. At that time the total sugar crop was only 1,500,000 tons, or less than one-sixth of what it is now. More striking still is the fact that of this crop over 1,250,000 tons, or more than eight



By permission of the Queensland Government

UNLOADING SUGAR-CANES AT THE FACTORY

per cent. of the world's production, was obtained from the sugar-cane: its present formidable rival, the sugar-beet, contributing only about 250,000 tons, or about sixteen per cent. of the total.

The actual figures are worthy of careful study.

COMMERCIAL SUGAR CROP OF THE WORLD

	Cane-Sugar.		*Beet-Sugar.*	
Present day	4,000,000 tons	40 per cent.	6,000,000 tons	60 per cent.
Fifty years ago....	1,250,000 ,,	84 ,, ,,	250,000 ,,	16 ,, ,,

During the last half a century the total production of sugar in the world has increased from 1,500,000 tons to 10,000,000 tons, or, approximately, has been multiplied by seven. The output of cane-sugar has been multiplied by three, but in the same period the output of beet-sugar has been multiplied by no less a figure than twenty-four. Europe produces practically all the beet-sugar of the world, for although the industry has made considerable progress in the United States the total output of beet-sugar from that country is not as yet more than one-fiftieth of the world's annual sugar crop. The history of this extraordinary development of an industry is dealt with under beet-sugar, but it will be well to point out here that it has mainly been due to the application of science. It is the joint work of the chemist, the botanist, the engineer, the cultivator, and the manufacturer, and by their co-operation there has been built up in Europe an industry which, allowing an average value of £10 per ton for the raw sugar, is now worth £55,000,000 annually.

The following figures indicate the average annual production of sugar for the last five years from the five continents of the world. They serve to show the pre-eminent position of Europe as a sugar-producing region.

Very carefully compiled tables of the production of sugar in every country are compiled annually by Messrs. Willett & Gray and Messrs. Licht, and these tables have been used for the preparation of the figures here given.

	CANE-SUGAR. *Tons.*	BEET-SUGAR. *Tons.*
America	2,700,000	170,000
Asia	946,000	
Africa	295,000	
Australasia	167,000	--
Europe	28,000	5,771,000
	4,136,000	5,941,000



SUGAR FACTORY—COOLING BOWLS

It should be remembered, however, that India probably produces close upon 3,000,000 tons of cane-sugar per annum, which being consumed locally does not appear above, and if we add this the total production of the cane would exceed 7,000,000 tons.

THE SUGAR-CANE

The sugar-cane is a large grass, growing far taller than any grass with which we are familiar in temperate climates, luxuriant plants reaching twenty or more feet in height. In spite of its size the



By permission of the Queensland Government

CARTING · SUGAR-CANE



INTERIOR OF AUSTRALIAN JAM FACTORY—BOILING PANS

habit of the plant is distinctly grass-like, and we find a group of stems of equal size springing from the ground in a clump, each bearing long, grass-like leaves, and terminating in the flowering season in a feathery plume somewhat like the more familiar Pampas Grass. The stems are commonly as thick as bamboos, such as could be used for curtain poles or the legs of a small table, but instead of being hard and woody outside and hollow within, they have a tough rind and are solid, with fibrous strands running through the soft sugar-containing tissue.

The sweet juice of the sugar-cane stem was appreciated in very early times, and the preparation of solid sugar from it was practised long before the Christian Era. History records that Alexander the Great feasted on "solid honey not made by bees." The Greek physicians appear to have known sugar under the name of "Indian salt."

The native country of the plant is not known with certainty, but in all probability it was in the region of Cochin China, India, or Malaya. Thence it spread to Africa and later to America. These wanderings having taken place during the historical period can be traced with some approach to certainty.

The sugar-cane was early cultivated in Egypt, Sicily, and Spain, to which countries it was introduced by the Arabs. From Sicily it was introduced into Madeira, and thence to the Canaries about 1425 A.D. by Don Henry of Portugal. Soon after the discovery of America the sugar-cane was introduced into the tropical part of the New World, reaching Hayti and Brazil early in the sixteenth century, and spreading thence to Mexico, Guadeloupe, Martinique, and later to Bourbon. In Hayti, as recorded by Porter in his work on the sugar-cane, the cultivation proved so successful and extended with such rapidity that the cost of the magnificent palaces of Madrid and Toledo is stated to have been defrayed by the proceeds of the port duties on the sugar imported from the island. The sugar-cane reached Barbados from Brazil in 1641, and was distributed thence to other West Indian islands.

The cultivation of the sugar-cane is only profitable in the tropics and in some sub-tropical countries. It is characteristically a tropical plant in its requirements, thriving best under an average temperature of about 80° F. and a rainfall of at least 60 inches per annum, or an equivalent artificial supply of water. As indicating the range of climates in which the sugar-cane will live, even if not at its best, we may mention that it is grown on a commercial scale in the south of Spain, in Japan, and it will grow in Cape Colony and New Zealand. In sub-tropical countries such as Louisiana and Natal it does fairly well so long as the conditions are favourable, but the sugar-cane is at its best in such lands as India, Cuba, Java, British Guiana, Hawaii all thoroughly tropical regions. Cuba and Java together produce about one-half of the commercial cane-sugar supply of the world, each exporting at present over 1,000,000 tons per annum.

Cultivation

The details of sugar-cane cultivation differ in various countries according to local conditions. In British Guiana, the Straits Settlements, Hawaii, and Egypt, irrigation is practised to a greater or less extent. In countries where land is plentiful, virgin soil is cleared and planted,



ISIS·CENTRAL SUGAR MILL



Photo by W. G. Freeman
A GERMINATING SUGAR-CANE TOP

whilst in many sugar-producing countries all the best land is already in use, and intense cultivation is the rule. The land may be broken up into ridges and furrows, or so-called "holes," made, as adopted in Barbados and Mauritius, to prevent washing of the soil by rain. Machinery is extensively employed in Louisiana and other places where labour is expensive or scanty.

The number of years for which ratoons are maintained naturally depends again upon local circumstances. In many countries the cane will ratoon with sufficient vigour for about five or ten years. There are examples, however, that the planter may reap from the same field much longer, for fifty or sixty years or even more, but then the climate and the soil must be very favourable indeed. In other places, *e.g.*, several parts of the West Indies, the fields are rarely left for more than three years without replanting, or again only plant-canes and first ratoons are taken, or in other cases the canes are planted fresh each year. This is especially the case where the plantations have been cultivated for some time and the conditions are accordingly less favourable. In Java, for instance, experience has shown that after the first year the quantity as well as the quality of the crop diminishes. For this reason the plants are not only renewed every year, but they are also planted in a different field the second year, so that rotation of crops is followed and the cultivation is made as intense as possible. Sugar-cane is followed frequently by beans and maize, these by rice. Then beans and maize again, and still another rice crop before sugar is once more cultivated on the same land, three years after the immediately preceding sugar-crop. People learned these methods of intense cultivation from a treatise by Don Alvaro Reynoso, Professor of Agricultural Chemistry in Cuba, which was translated into Dutch in 1865. Reynoso chiefly advised a thorough breaking up of the soil sixteen inches deep, planting at proper distances, and systematic draining. An enormous amount of care and attention has recently been devoted in Java, the West Indies, Hawaii, the United States of America, etc., to the problems of the manurial requirements, etc., of the cane. Analyses show that a crop of sugar-cane of about thirty tons to the acre contains approximately thirty pounds of nitrogen, seventy-five pounds of potash, and twenty pounds of phosphoric acid, all of which has been removed from the soil. If the soil is very rich in these substances there may be no need to replace these essentials in the form of manure for some period. Sooner or later, however, on most estates there comes a time when the available stock of nitrogen, potash, and phosphates is exhausted, or depleted to a sufficient extent to interfere with the successful cultivation of the crop. The planter then has to face the serious question of how to apply these valuable constituents in the most useful and economical manner.

As an instance of the careful manner in which practical questions such as this are dealt with by the modern scientific departments of the colonies, we may take the case of the investigations conducted by Dr. Francis Watts, of the Imperial Department of Agriculture for the West Indies, into the manurial requirements of the sugar-cane in the Leeward Islands, *i.e.*, in Antigua, St. Kitt's, and Nevis. For the last six years very careful experiments have been carried out on actual sugar estates, with the general result of ascertaining that an application

of twenty tons per acre of pen manure (corresponding to farmyard manure of this country) is sufficient, and that there is as a rule no remunerative return gained by adding chemical manures in addition. This result is of great economic importance, otherwise large sums of money might be, as in places they are, wasted annually in the mistaken idea that benefit was being done to the crop. The fact is too often overlooked that the ill-directed application of manures may actually do harm and diminish instead of increasing the crop. Very elaborate and valuable experiments have also been conducted by Prof. J. B. Harrison in British Guiana, and it is interesting to note that both workers agree that the richness of the cane is not influenced by manuring. The percentage of sugar in the juice of a cane is a characteristic which does not alter with differing manurial treatment, and that when a larger crop is obtained it is due to the manure having encouraged a heavier growth of cane, and not a crop of the same weight but richer in sugar.

Planting. The soil is cleared of weeds, well tilled, and furrows are dug three or four feet apart and about one foot deep. The tops or cuttings are set almost vertically in holes made in the furrows, or sometimes, *e.g.*, in Louisiana, and also in Cuba, whole canes are laid down in the furrows. The roots soon develop, and shortly after one culm or stem shoots up, then another, until four or five stems have arisen from the little buds on the original cuttings as shown in the illustration. During the growth the field must be kept clean by weeding and hoeing, until after about eight months the canes have reached their full heigh. Then the lower leaves are partly withered, and in some places the custom is to strip the plant of those dry leaves. This causes the stems to stand up more firmly, and admits sunlight and air. This practice is not essential in all countries, and is not always adopted.



REAPING SUGAR-CANES IN THE WEST INDIES

Sugar-cane being generally grown in the tropics, hand labour is principally employed for various reasons, but in Louisiana, for instance, much of the cultural work is performed by the help of machinery, partly due to the scarcity of cheap labour. Steam-ploughs have been introduced into Trinidad by the Trinidad Estates Company, and are estimated to do the work at slightly less cost than when animal traction is resorted to, and at not much more than one-half the cost of manual labour.

After about ten months some flowers may appear, but by no means on all plants: some varieties never bear flowers at all, and in the cooler sub-tropical countries a flowering cane is the exception.

The best moment for the cutting and further treatment of the sugar-cane, that is to say, the moment when the sap is purest and at the same time most plentiful, is when the flowers have faded. Fortunately, the quantity and the quality of the juice remains stationary for a fairly long time, but as soon as the growth ceases the sap gradually begins to dry



PENANG. BARGES LOADED WITH CUT SUGAR-CANES

up, and a chemical change begins to operate, other substances being formed at the cost of the pure sugar.

That the quantity and the quality of the sap remains stationary for some time is especially fortunate for this reason, that as a rule the circumstances do not allow of cutting the whole crop at once. This must be done according to the capacity of the factory; cut canes rapidly deteriorate, and only an amount should be reaped which can be dealt with immediately.

Under favourable climatic conditions the cane thrives without artificial watering. In some countries irrigation is extensively practised, either because it is necessary or because greatly increased yields result and render it profitable. Hawaii affords, perhaps, the most conspicuous example of the wise expenditure of money on costly irrigation works. The soil is fertile and this fact, combined with judicious irrigation, has resulted in yields of over 100 tons of canes per acre being obtained, which is perhaps four times as much as the average yield in most cane-growing countries. In Java, Egypt, Cuba, Mauritius, and British Guiana irrigation is practised to a greater or less extent, and in Peru it allows canes to be cultivated successfully in regions where the rainfall is nil.

Reaping. None of the nations which still keep true to their primitive religion, and that is especially the case with the people of the Eastern tropics, will ever reap a harvest of any importance without some preliminary solemn offering to the goddess of fruitfulness. In the case of very important products, prayers and offerings are also sent up to the goddess before the planting is begun, and at the same time the evil spirits which may harm the growth or the crop are often exorcised or propitiated. A simple prayer and a meeting suffice for the planting of the sugar-cane. But people make up for these scanty solemnities at the harvest-feast, when the first canes are taken to the factory. Even in Europe harvest festivals are not unknown, and it is not so long ago that these bore a strongly religious character. In Java these feasts are celebrated with considerable ceremony, especially on the principal sugar estates where a large number of people are employed.

A few days after the harvest-feast the real harvest begins. The canes which were planted first the year before are also cut first, a little above the ground, with a long knife or cutlass—rather heavy work in the tropical heat. Many attempts have been made to substitute

reaping or cutting machines for hand labour. The great size, uneven mode of growth, and tangled character of luxuriant sugar-canes make the problem a very difficult one to solve satisfactorily, and no machine has met with general approval. Various machines have, however, been tried experimentally in Queensland and Louisiana. Labourers collect the cut canes, tie them in bundles, and take them to the carts standing ready to convey them to the factory. On most of the estates the carts are drawn by cattle, buffaloes, oxen, or mules. In other cases the canes are borne on the backs of donkeys and mules. In the last twenty years, however, technical science has made enormous progress, especially as to means of transport, so that nowadays large factories often possess a complete set of easily removable rails, running from the factory to the plantations, on which cars, specially built for the purpose, go to and fro, drawn either by animals or by locomotives (see the illustration of transporting canes in Queensland). In other countries, again, for instance in British Guiana and the Straits Settlements, the conditions allow of barges transporting the canes to the factory. Mechanical arrangements for loading and unloading carts and barges are employed with success in some countries, e.g., Louisiana, Cuba, Trinidad, and British Guiana.

Arrived at the factory every full waggon is put on the bascule and the net weight of the canes is noted down, so that the manufacturer knows exactly how much the crop of each field and also that of all the fields together weighs. This is of great importance, for now the chemist extracts the juice from a certain amount of canes by way of experiment and determines how much juice it should be possible to extract from the whole crop; then he determines the density of the juice, and also the "coefficient of purity," from which data may be calculated in a fairly simple manner how much sugar, capable of being crystallised, should be obtained.

Manufacture of Sugar

Crushing. The oldest machine used to extract the juice from the canes consisted of two upright rollers, about an inch apart. The picture on page 90 shows such a machine of very primitive construction. One of the two rollers was longer than the other, to allow of its



QUEENSLAND. CARRYING CUT CANES TO THE FACTORY

being connected with a lever, which, worked by men or animals, caused it to revolve. Now, if a man fed the machine with sugar-canes while the one roller was revolving, the second roller was made to revolve in an opposite direction, and the juice was squeezed out to a certain extent. Some of the early mills, *e.g.*, those of the Chinese, were so light that they were carried about and the crushing done in the field. The discovery of the means of transferring motion made it possible to place the rollers in a horizontal position without changing the direction of the motive power. The great advantage was that the rollers could be made much heavier, and so exercise greater pressure. Once it was possible to use horizontal rollers, first stone and later ribbed iron cylinders of very large dimensions and enormous weight were used, first in the largest factories and afterwards also in the smaller ones. A few more years elapsed, and people saw the advantage of using a third roller, so that the chief factories began to work with three rollers, arranged in a series, the third above and midway between the two others. In this way it was possible to extract much more juice from the canes than with the primitive wooden rollers. One, two, or more rollers are sometimes added, but three-roller mills are very generally adopted. In large factories two or three sets of three rollers each are employed. The illustrations afford good examples of very primitive and also of modern cane-crushing machinery.



JAVA. A PRIMITIVE SUGAR-CANE MILL WORKED BY BUFFALOES

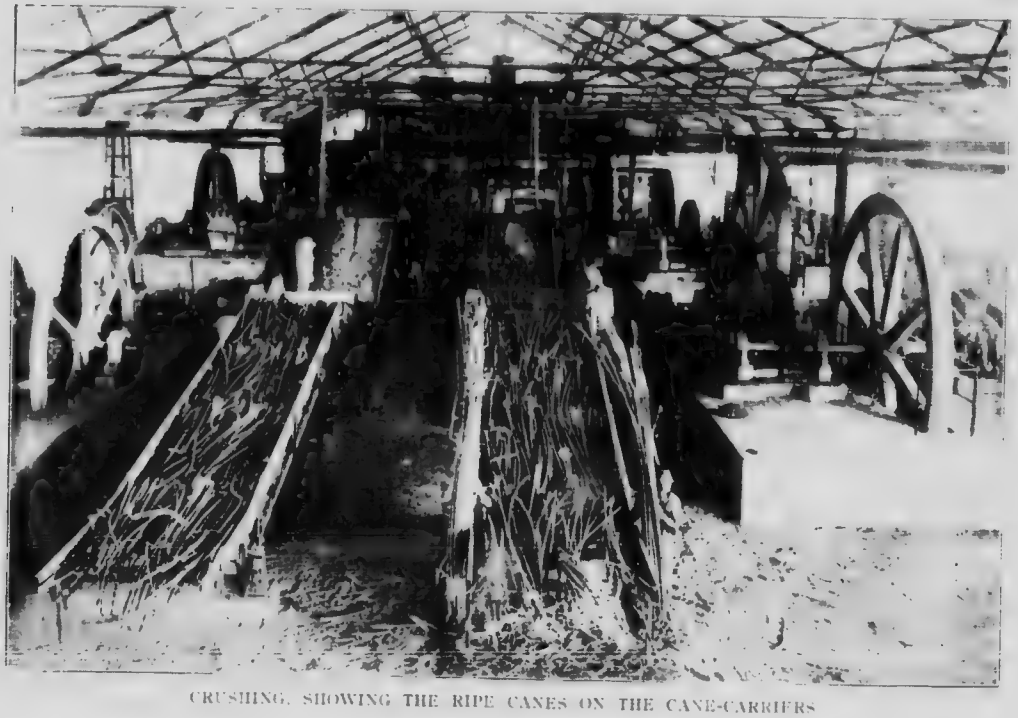
Sugar-cane mills are usually driven by steam-engines, although in a few instances, *e.g.*, in Barbados, the wind is still relied on largely as the motive power, and windmills are a characteristic feature of the landscape. Barbados lies in the track of the trade winds which usually blow steadily during the crop season, but even under these favourable conditions delays often occur, and steam has been substituted as the motive power on the larger estates.

The great increase in size, weight, and power which has taken place in sugar-cane mills has naturally also brought about changes in other directions. The framework of mills has had to be strengthened to a corresponding degree, and the engines have been immensely improved. A source of trouble is mill breakages, which sometimes take place owing to sudden variations in the amount of cane passing through. It is practically impossible to maintain a uniform feed of cane, and various devices, of which the hydraulic attachment is the most important, have been adopted. The hydraulic attachment automatically separates the bearings of the rollers when the strain becomes greater than is safe. Another great improvement, to be found on even comparatively small estates, is the automatic feeder. The original process of putting the canes into the mill by hand has been replaced usually by an endless belt on which the canes can be placed direct from the cart or truck bringing them from the field. The belt is constantly in motion, and the canes are carried up and discharged into the mill. Where two or three sets of rollers are employed, other carriers transport the crushed cane or megass from the first mill to the second, and from the second to the third, aided by hand labour to ensure the soft megass being gripped by the mills, or by other mechanical devices

CLARIFIERS

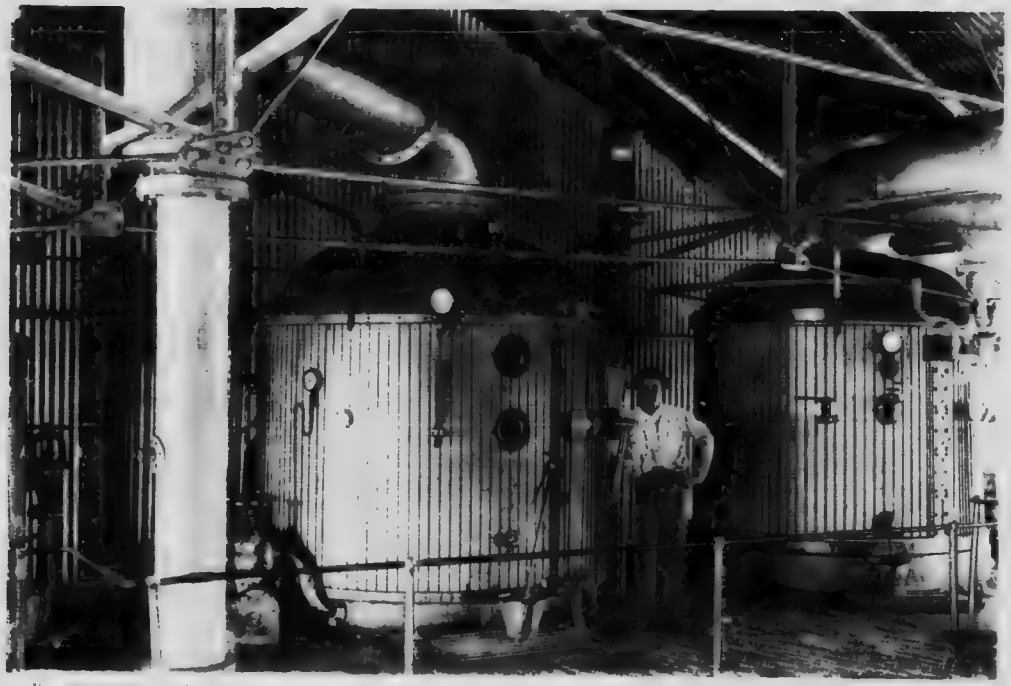
What modern milling is very much more efficient than the old, it must be recognised that no method of crushing alone can extract all the juice from the cane. The practice most frequently adopted of moistening the megass with hot water at the moment that it leaves the first mill. On passing this moistened megass through the second mill, a much weaker [illegible] juice [illegible] more sugar per cent. per dingly extracted, but longer exposure to more [illegible] to proceed to hot dilute the [illegible] juice, and unless more is extracted [illegible] may more than [illegible] the [illegible] value of the sugar gained.

In the manufacture of [illegible] the maceration or [illegible] of the cane with water after the [illegible] has been made from time to time to apply the process to the [illegible]. The [illegible] appears to have been made in the French West Indies, Martinique and Guadeloupe, about the middle of the last century, but the [illegible] not successful. The essential difficulty is that the sugar-cane planter has practically to rely on the megass for his fuel, coal is too dear in the tropics to use, and the megass left after maceration is inferior to that obtained by crushing, and at the same time the greater dilution of the juice necessitates a larger amount of fuel. Maceration methods, pure and simple, have been generally abandoned for sugar-cane. An interesting process known as the Naudet Patent Process has recently been devised, and is being worked in Egypt, and Madeira, and at Porto Rico, Trinidad, and other parts of the West Indies. The canes are first crushed in an ordinary mill, and the megass is passed on to one cell in a battery of eight, whilst the juice is limed and heated. The hot juice is then added to the megass in the cell, and drawn off through it, so that the megass is macerated and has its residual sugar to a great degree extracted, and at the same time is employed as the filtering agent for the juice. The megass is subjected to successive washings, and finally crushed again in another mill and used in the ordinary way.



CRUSHING, SHOWING THE RIPE CANES ON THE CANE-CARRIERS

FIG. 1 MODERN STEAM AND MILL



VACUUM PANS

as fuel. It is estimated that in this process about ninety-five per cent. of the sugar is extracted from the cane. Whereas in ordinary single crushing we only obtain about seventy-five per cent., in double crushing eighty-three to eighty-eight per cent., and in triple crushing ninety to ninety-two per cent.

Defecation and Filtration. The juice flows from the mill as a dark, greenish-yellow liquid, not attractive to the eye, but with the pleasant odour of sugar-cane juice and distinctly sweet to the taste. Analyses show that cane juice as expressed contains, on an average at any rate in the West Indies, about fourteen per cent. of cane-sugar. In addition the juice has two kinds of impurities. There are small pieces of the tissues of the stems which have come over from the mill, accidental additions, particles of dirt, etc. There are also impurities dissolved in juice, the albuminoids, salts, and other normal ingredients of the sugar-cane sap, which, although perfectly harmless, are not sugar and must be removed.

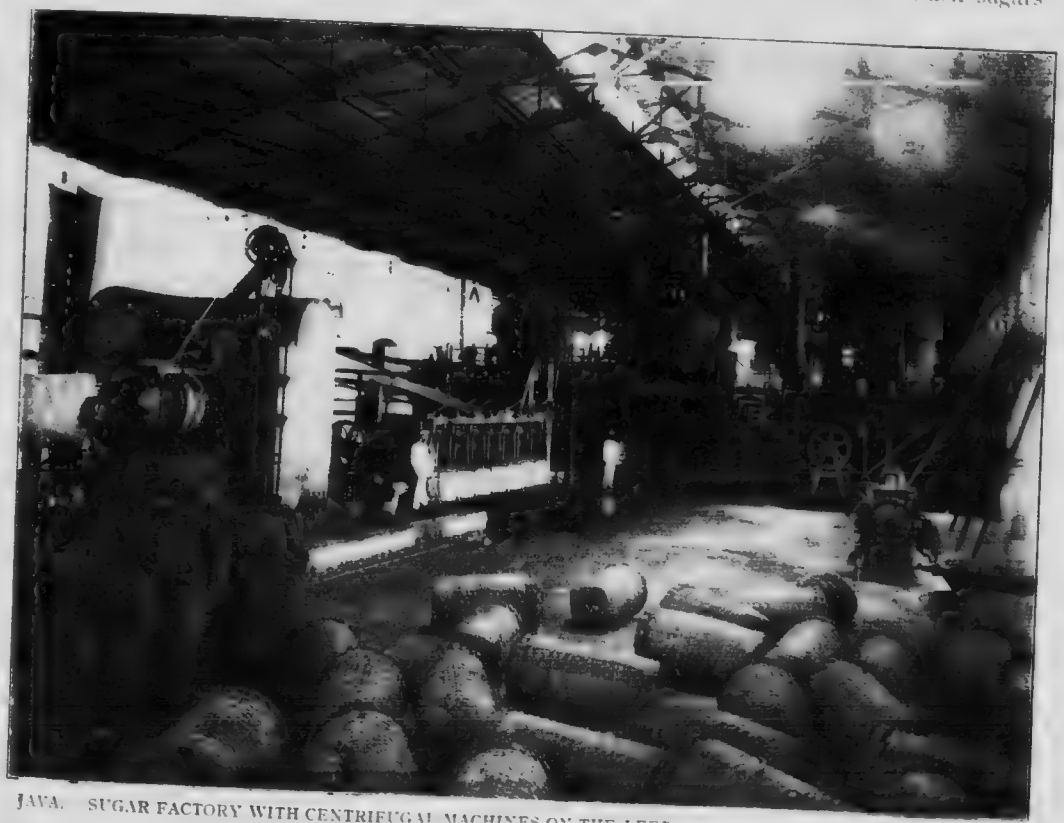
Large particles are readily got rid of by simple straining. After this has been done means are taken to (1) coagulate and thus render insoluble the previously dissolved albuminoids and other substances, and (2) to remove these with any other material which has escaped the rough straining process.

The coagulation of the albuminoids is effected partly by heating the juice. This has another important result inasmuch as it kills the ferments naturally present in the plant, and prevents further changes going on in the composition of the juice.

It is also well known, however, that if a solution containing cane-sugar is heated and particularly if the mixture is slightly acid, as sugar-cane juice is as it leaves the mill, some of the cane-sugar will be inverted, as it is technically termed, into other forms of sugar which are of less value to the manufacturer. To guard against this a certain quantity of lime, in the form of milk of lime, is added to the juice. The lime plays more than one rôle. It removes

the acidity of the juice and so retards the inversion of the cane-sugar, and it assists in rendering insoluble the albuminoids and the various mineral substances also present. This process of heating the juice to which lime has been added is usually spoken of as "defecation," and has been practised from very early times. It is often carried out in large open boiling pans, like huge kitchen-coppers. The juice is run in from the mill, the proper amount of milk of lime added, and the whole contents of the copper heated rapidly to boiling point. The impurities rise to the top as a scum, and may be removed to a great extent by skimming. Other vessels are designed so that part of the impurities settles to the bottom, and parts form a scum on the top, whilst in between is a clear liquid which can be drawn off at will by a suitably placed tap. Various other devices have also been designed, but the essential is the same in each case.

After liming and heating it remains to remove as completely as possible all the impurities now reduced to an insoluble state so that they can be got rid of by filtration. This is done by passing the juice through various types of filter bags, or the more modern filter press. It will be noted that the Naudet process described above allows of the heating and filtration being performed practically together, and moreover uses the megass or crushed cane itself as the filtering medium in place of special filter bags or presses. Defecation as described above is superseded by the carbonatation process on some sugar estates. This method is described under the beetroot-sugar manufacture. The juice obtained by these methods, when well carried out, is beautifully bright and clear, but dark in colour, so that it finally yields dark sugars, of the type of the good and formerly more extensively used moist brown sugar, or muscovado of the British West Indies, or the "basket" sugar of the East. Such sugars

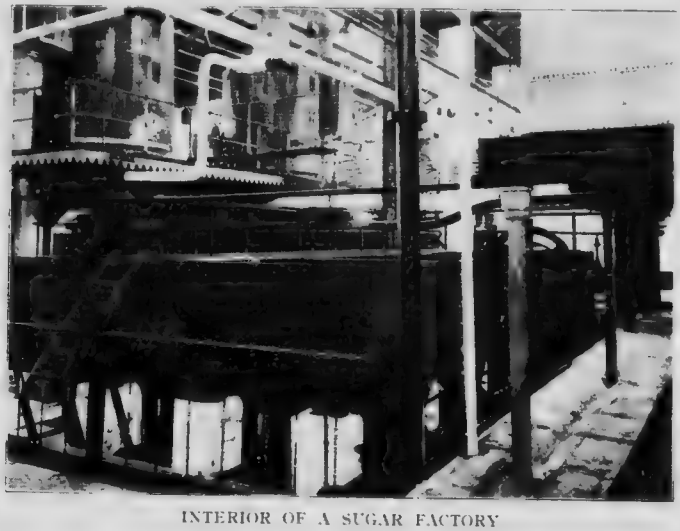


JAVA. SUGAR FACTORY WITH CENTRIFUGAL MACHINES ON THE LEFT AND VACUUM PAN IN BACKGROUND

nowadays are principally used for refining purposes, and for table use whiter sugars are preferred. To obtain these the juice has to be bleached, and this is usually done by submitting it to the action of sulphurous acid, generated by roasting sulphur and passing the fumes into a tank containing the juice which may or may not have been already defecated. In either case the sulphuring is additional to and not in place of the defecation process.

Boiling. The clarified and filtered juice is now ready to be boiled down into syrup of sufficient concentration to allow sugar crystals to be obtained from it. The dilute liquor is first evaporated down to a syrup; this is further concentrated to the pasty *masse-cuite* consisting of crystals embedded in the thick syrupy liquor, and from the *masse-cuite* the crystalline sugar and the uncrystallisable molasses are separated.

In no portion of the process of sugar manufacture have such improvements been effected during recent years as in the mode of boiling, and in all up-to-date factories, the open boiling



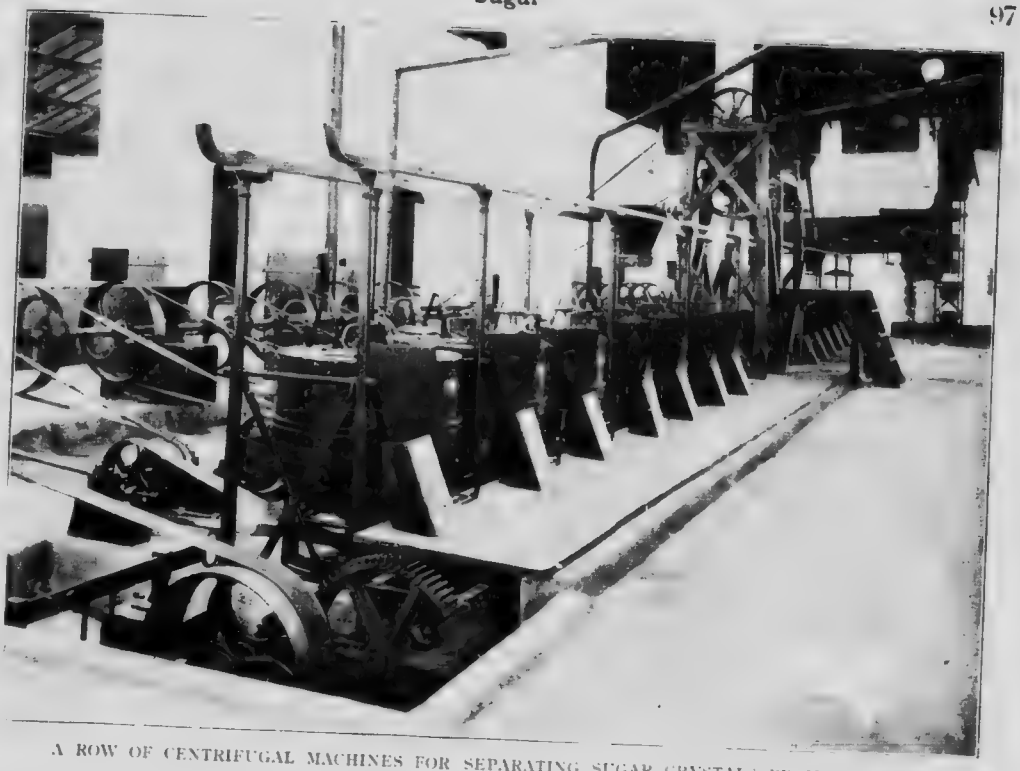
INTERIOR OF A SUGAR FACTORY

pans have been replaced by modern "triple effects" and vacuum pans. The old-fashioned open boiling, still employed for special reasons on some estates in the West Indies, in India, and elsewhere, was conducted in this way. Some four or five large hemispherical copper pans were arranged in a line above a flue so that they were all heated by a fire generated at one end, directly under one of the pans. Frequently the pans or "tayches" were of different sizes, the smallest being placed immediately over the fire and the largest at the greatest distance. When the set is in working order all are boiling at once and fresh supplies of clarified juice are introduced into the largest tayche as required, whilst each of the other tayches is kept full by ladling liquor into it from the one farther away from the fire. The result is a series of pans containing liquors of various degrees of concentration, because as the juice in No. 1 begins to concentrate it is ladled on to No. 2, from No. 2 to No. 3, and so on until it reaches the last pan, the smallest one, placed directly over the fire. The scene in a sugar-boiling house, with the row of huge bubbling cauldrons of syrup, which is continually being stirred and transferred from one cauldron to another by means of long ladles, is very interesting, however much it may fall short of modern ideas. In the last tayche evaporation is continued until the mass is ready to crystallise out on cooling. As soon as this point is reached it is ladled out into the coolers, shallow, rectangular stone



From a photograph by N. T. Lascaris, Littlehampton *Coloured by Mrs. W. G. Freeman*

SANTA CRUZ A FIELD OF SUGAR CANE



A ROW OF CENTRIFUGAL MACHINES FOR SEPARATING SUGAR CRYSTALS FROM MOLASSES

cisterns. After remaining here for two or three days the whole mass, now consisting of sugar crystals and molasses, is dug out and put into sacks or hogsheads to drain, the molasses or treacle draining away and being collected elsewhere, whilst the sugar remains behind. This is in brief the most primitive way of manufacturing sugar on a considerable scale. It is in some respects very wasteful. Evaporation in open pans necessitates high temperatures being attained, and consequently the amount of inversion which takes place is greater. The separation of sugar crystals and molasses is very imperfect. One point in its favour is that it yields excellent molasses, but whether this is sufficient to compensate for loss in other directions is a question to be settled according to special conditions on the estate. From the sugar-producing point of view improved molasses means loss of possible sugar.

We will now turn to indicate in outline more modern methods, which have been adopted mainly from the rival industry as competition between the two increased.

The loss of crystallisable sugar owing to its being inverted at the high temperatures necessary when the syrup is evaporated in an open vessel was overcome by making practical use of the well-known physical law that liquids boil at a lower temperature if the atmospheric pressure is reduced. The vacuum pan was invented in which the partially evaporated syrup underwent its final concentration under very low atmospheric pressure. Accordingly it "boiled" at a much lower temperature and there was correspondingly little loss from inversions. Still further advances led to the replacement of the whole series of taveches by a series of vessels, three being usually employed, and the set known as a "triple effect." Not only do the triple effect and vacuum pan economise sugar, but they also economise fuel, and they are used in all large modern factories. They are not heated at all directly over a fire, but internal steam coils are made use of. The vacuum pan is made with small glass windows at the sides: on looking

through one can see the whole syrupy contents, and the expert sugar-boiler can tell by their appearance when the critical moment has arrived and the sugar is ready to crystallise. To ascertain this with even greater precision, by means of an ingenious invention, the "proof stick," small samples of the boiling contents may be taken out from time to time without in any way breaking the vacuum. The sample of syrup withdrawn is allowed to form a thin sheet on a piece of glass, and from the appearance of this as it cools the condition of the contents is judged. When ready to crystallise or "grain," the temperature is lowered suddenly, and small sugar crystals are formed. These become more numerous, and when judged to be sufficiently numerous more syrup is added and the temperature raised again. Various modifications in treatment now follow according to whether a large or a small grained sugar is being made. In any case very careful attention is required to obtain the pan full of crystals with a minimum of liquor. When the ideal has been reached, a door at the bottom of the pan is opened, the contents flow out, and we have only to separate the crystals from the molasses.

Separation of Sugar from Molasses. There are various methods by which this can be done, but they have all given way to the common process of using centrifugal separators. These consist essentially of cylindrical metal vessels which can be made to revolve at a very high speed. The walls of the separators are pierced by a number of holes, and on the inside there is a lining of very fine metal gauze, of sufficiently small mesh to prevent sugar crystals passing through. The separators, which are open at the top, are partly filled with the mixture of sugar crystals and molasses, and set rapidly rotating. The centrifugal force causes all the contents to fly to the outside and remain, as it were, pressed against the wire gauze. The crystals are held there, but the liquid molasses passes through, is caught in a receiver, and conducted away. One may stand and watch the whole operation, which is over in a very few moments instead of the weeks required by the earlier methods. As soon as the motion ceases, the crystals collect at the bottom of the separator, which can be opened to allow them to drop out, and they are ready to be packed and exported immediately



WHITE BEETROOT RED BEETROOT

The left-hand member of each pair has been grown without, and the right-hand member with, manure

To get rid of the last remaining molasses the crystals can be washed whilst the separator is revolving, this not being necessary in preparing a "moist" sugar.



From Stereograph Copyright *Underwood & Underwood London and New York*

BLOSSOM OF COCO-NUT PALM

The sap collected from the cut young flower stalks yields sugar

BY-PRODUCTS OF SUGAR MANUFACTURE

The chief by-products obtained in the manufacture of sugar from the sugar-cane are (1) the megass or crushed cane stalks left by the mill; (2) molasses; (3) rum, made from the molasses.

Megass

Fuel. The refuse material from the mill known as megass, or by the Americans, "bagasse," is of great value to the tropical sugar planter, as on it he relies for the heat necessary to evaporate the juice into crystallisable syrup. A West Indian estate yard, in crop season, was formerly covered with the megass taken from the mill and spread out to dry. The introduction of improved furnaces which burn "wet" megass has done away with the necessity of this to a great extent, with consequently a considerable saving, as it was expensive in labour to handle all this material. It is estimated that megass as delivered by a good modern nine-roller mill is worth as fuel approximately one-third its weight in coal. Such megass contains nearly half its weight of water, but yet can be at once burnt in the new furnaces. Poor mills leave a high percentage of sugar in the megass, and although this may enhance its value as a fuel it is a very serious loss to the planter. In ordinary circumstances, with up-to-date machinery the quantity of fuel required is much less than in the days of the old, wasteful, open-pan boiling, and instead of having to supplement his megass by wood or coal, the modern sugar-maker finds it difficult at times to get rid of the surplus megass.

Molascuit. During quite recent years a process was patented by Mr. T. Hughes whereby the finer portions of the megass, consisting really of small fibrous elements of the sugar-cane stem, were employed to absorb molasses, and to form a cattle food. The little tubes of the megass became filled, and the whole mass saturated with molasses, and yet the net result is a powdery material as conveniently handled as an ordinary moist sugar. This product, known as "molascuit," is prepared now in many parts of the cane sugar producing world, and is rapidly progressing in favour as a cattle food.

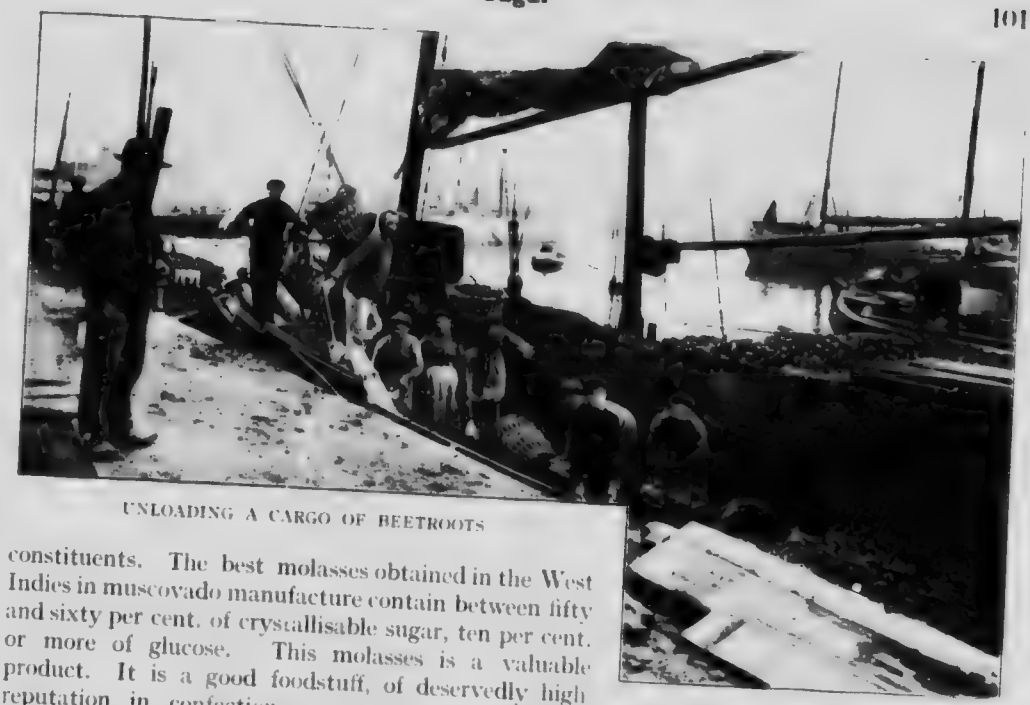
Filtering Medium. The utilisation of the megass as a filtering medium has already been referred to under the Naudet Process.

Molasses

The use made of molasses cannot be summed up in a few words because in the first place the molasses obtained in the muscovado process, and that obtained from a modern vacuum pan are of very different value. The molasses contains the uncrystallisable residue, and the nature of this "residue" depends very greatly on the method of making sugar employed. In the muscovado system inversion sets in very rapidly when a high temperature is reached, and accordingly the concentration cannot be carried to anything like the degree it can in a vacuum pan. The result is that much more crystallisable sugar—sucrose—remains in solution, along with the uncrystallisable sugar—glucose—and the various mineral



GATHERING BEETROOTS



UNLOADING A CARGO OF BEETROOTS

constituents. The best molasses obtained in the West Indies in muscovado manufacture contain between fifty and sixty per cent. of crystallisable sugar, ten per cent. or more of glucose. This molasses is a valuable product. It is a good foodstuff, of deservedly high reputation in confectionery as a sweetmeat, etc. Barbados, Antigua, Porto Rico, and other West Indian Islands export large quantities of molasses in huge casks or puncheons to the United States, Canada, the United Kingdom, and elsewhere, and in certain circumstances molasses is more remunerative than sugar; but of course there is a comparatively small market. With the adoption of improved processes for extracting the sugar the amount remaining in the molasses is reduced, and in vacuum pan molasses it is about thirty and thirty-five per cent. of sucrose with an approximately equal amount of glucose. Such molasses are of little value for table use and confectionery, they do not yield a palatable spirit if fermented and distilled, and cannot be employed like higher grade molasses in the manufacture of rum. They will, however, yield an alcohol which can be used for industrial purposes. In other cases they are used as fuel, the megass being sprinkled with molasses before being fed to the furnace, or the molasses are burnt in specially constructed furnaces, so made that the potash salts which the molasses contain can also be recovered.

Manufacture of Rum

Molasses will undergo fermentation exactly as other saccharine substances which offer conditions suitable to the life and activity of the yeast plant. In temperate climates much scientific research has been devoted to the study of the yeast plant, and cultivated races are bred which can be relied on, when placed under proper conditions, to bring about certain results. In the tropics, as a general rule, this has up to the present been neglected, and everything left to chance. Recently, however, in Jamaica, long famous for its rums, a special fermentation chemist has been appointed and the whole industry of rum manufacture in the colony is being carefully studied with the object of improving the quality of the product, and of formulating reliable rules for procedure. The usual practice in sugar-cane countries is to dilute molasses with water, and in some cases sugar-house skimmings, fresh cane juice, and various other materials are added. The yeast is left to chance, but yeasts are omnipresent, and there is little likelihood of some of these minute plants not falling from the air into the "wash,"



A STORE-HOUSE FOR BEETROOTS

together with bacteria and other air-borne organisms. As the yeasts multiply the liquor begins to "work," and the fermentation is allowed to proceed for two days or more. When the fermentation is completed the alcohol formed is obtained in the ordinary way by distillation, various types of stills being employed in different localities.

Fresh rum is not pleasant, the characteristic aroma developing with age. The pure spirit is colourless, but it is the custom to colour rum by means of caramel, usually made by burning molasses. In the West Indies rum manufacture is principally practised in Jamaica, Demerara, and Barbados, although conducted on a small scale in other colonies. Rum is also made in Mauritius, etc. In Java and other places in the East, the methods adopted of making spirit from molasses differ in various ways, the ferment being generally introduced in the form of the little balls known as "Ragi," the preparation of which has already been described in dealing with the utilisation of rice as a source of alcohol.

Improvement of the Sugar-Cane

From the proof in 1880 of the important fact that sugar-canes, contrary to what had previously been thought, bore seed, efforts have been made to raise new races of superior qualities to those already in existence. The credit of the discovery of the seed is shared between West and East: between Prof. Harrison and Mr. J. R. Bovell in Barbados, and Dr. Soltivedel in Java. Since that date seedling canes have been raised in large quantities, cultivated experimentally, and some of them are now grown on an industrial scale in various parts of the world. The Barbados canes, distinguished by the letter B, such as B. 208, B. 147. Demerara canes, *e.g.*, D. 95, and others, are now well known and appreciated, not only in the West Indies but also in Queensland, Louisiana, and other cane-growing countries. Similar work has been prosecuted in Java with successful results. Owing to the long period of time required for the thorough testing of new varieties of sugar-cane and other difficulties, progress must necessarily be very slow compared with the results from similar work on such a plant as the sugar-beet, but definite advances have been made although the results are not so sensational as were at one time hoped for. In the West Indies one of the most valuable features of the seedling canes is their increased resistance to disease, so that they can be cultivated in areas where the Bourbon, formerly the standard cane, can no longer be grown.

BEETROOT SUGAR

Beet-sugar, as has already been stated, comprises about six-tenths of the world's commercial sugar crop. The sugar-cane doubtless still yields more than one-half the world's total production, but India, for example, although it produces a large amount of cane-sugar, consumes it also, and India's output does not figure in the statistics of the world's commercial crop, to which the sugar-beet is the greatest contributor. The sugar-beet, which is clearly thus one of the most

important commercial plants of the world, is a variety of the common wild beet, *Beta maritima* which occurs on our own shores, and around the Mediterranean and Caspian Seas, in the Canary Islands, Persia, and may range as far as India, although there is some doubt as to whether it is actually wild in that country. The wild plant is not uncommon in Great Britain and in Ireland on the sea-shore, growing in sandy tracts, in crevices in cliffs, etc., with long, straggling, weak stems, and thick fleshy leaves. The root in the wild plant is fleshy, but nothing like the size of the cultivated varieties, perhaps one inch or a little more in the thickest portion is about the average.

From this wild stock have been derived, under cultivation, the table beet with its red, fleshy root, the mangold wurzel, and the sugar-beet with a white root.

The white and red kinds have been known for a very long time and were in cultivation before the Christian Era; now a very large number of varieties have been raised. Although the plant has been known for so long it is only recently that it has been employed as a source of sugar, and the development of the industry is one of the most striking examples of successful results attained by welding science and practice that the world affords.

Historical Account

The occurrence of sugar in the beetroot was noticed as early as 1590, when Olivier des Serres, in recording that the red beet had not long been introduced into Europe, adds that "the juice yielded on boiling is similar to sugar syrup." Previous to 1747 the beet was cultivated mainly as a vegetable for table use and as cattle fodder. In this year Marggraf, a member of the Berlin Academy of Sciences, conducted a series of researches on a large number of plants to ascertain their sugar contents. His results were communicated to the Berlin Academy in a paper in 1747, in which he urged the importance of the beet as the source of a possible industry. It is true that Marggraf's methods were only suited to the laboratory; moreover the price of sugar from tropical colonies did not warrant the sinking of a large amount of capital in such ventures.

The idea of a sugar industry founded on the beet lay dormant for half a century.



TRANSPORTING BEETROOTS TO THE FACTORY BY AN ELECTRIC TRAIN

In 1797 Achard, a French refugee and pupil of Marggraf, took up the work where his teacher had left it, and after much research was able to extract sugar from the beetroot on a considerable scale, and two years later he presented a sample of this sugar and gave a description of his methods to the Institute of France. Achard estimated that the cost of production should not exceed 3d. per lb. In spite of the doubt raised and the ridicule cast on his work, a considerable amount of interest was aroused and a commission of chemists was appointed to investigate his methods and repeat his experiments. In the report presented by the commission a summary is given of investigations on other sugar-containing plants, and attention is directed to the failure of experiments to introduce the sugar-cane and the sugar-maple into France. As to the beet itself they found a little over six per cent. of sugar in the roots, and by repeating Marggraf's methods they succeeded in producing a muscovado or raw sugar, of a dark brown colour, and disagreeable taste, at an estimated cost of about 9d. per lb. In concluding the commission state "that admitting the result of the experiments it remains to be demonstrated that the beet may up to a certain point supplant the sugar-cane."



DIFFUSERS IN A BEET-SUGAR FACTORY

The scene of activity was once again transferred to Germany, where in 1805 Baron de Koppy built a factory in Lower Silesia capable of dealing annually with 525 tons of roots. Achard also founded a factory of his own.

World politics furnished the next impetus. Napoleon I issued the decrees of Berlin and Milan, establishing a continental blockade, the object of which was to shut out all English products and manufactures, and in particular the products of the English colonies, among the most important at this period being sugar, indigo, and cotton. The actual results were that Achard's and Koppy's factories showed an increase in their profits, search in France for possible substitutes for English colonial produce was greatly stimulated, and also the French wine trade suffered great loss. Grapes even were seriously considered as a commercial source of sugar, and the government gave financial help towards rendering this possible.

A few years later, from about 1810 onwards, attention was again directed to beet-sugar, and the experimental work was once more repeated, and not only muscovado but white sugar was prepared, the cost of the former being estimated at 1s. 3d. per lb., and of the latter at 1s. 8d., although there seemed a reasonable hope that these prices might be reduced to 4d. and 6d. respectively. The Emperor gave practical assistance to the new industry, and in 1811 ordered about 80,000 acres of sugar-beets to be cultivated in the French Empire.

Curious means were resorted to to discredit or encourage the industry, as the case might be, and amongst the caricatures of the day was one of the Emperor Napoleon and the young King of Rome, the latter sucking a beetroot, with the legend beneath "Suck, dear, suck, your father says it's sugar."

Fostered during Napoleon's lifetime, the industry collapsed with its fall, and only one factory survived the wreck. Still the potentialities of the sugar beet had been demonstrated, and although languishing, the industry was not dead. Other factories by degrees were established, and in 1829, the first year of which we have statistics, the crop of beet-sugar was estimated at 4,000 tons. In Germany also the manufacture of beet-sugar lapsed with the fall of Napoleon, and was not taken up again until 1835.

In the United States of America, in spite of early experiments in 1830 the beet industry dates actually from 1863. The production in America is yet comparatively small, and the historical notes given above show that in Europe the present enormous industry has developed almost entirely during the last seventy to eighty years. Political considerations from the first played a most important part, and later the bounty system materially expedited progress, enabling the continental producers to market their sugar in other countries, actually below cost price if desirable, and yet to obtain sufficient remuneration to work at a profit from the artificially high prices a protective tariff ensured at home. The abolition, by the Brussels Convention of 1903, of all bounties, direct or indirect, and of undue preference to home-produced, as opposed to imported, sugar, has had the two-fold effect of reducing the price of sugar in continental Europe and of raising the price of the sugar exported from the same region. Cane and beet-sugar once again compete in the markets of the world on equal terms.

The beet is one of the group of plants known as biennials, taking two years before it flowers and fruits. It is propagated by seed, and in its first year produces, above ground, only leaves, which elaborate large quantities of food reserve which is stored up underground in the large fleshy root in the form of sugar. If left to itself the plant remains dormant during the winter and in its second season flowers and fruits, using for this purpose the store of surplus food accumulated during the preceding year. Man, as in the case of the sago palms, which, however, take several years to attain their maximum store of food, interferes, and at the end of the first year appropriates to his own uses the supplies the plant has put by for the benefit of the succeeding generation. Special beets, carefully selected, are allowed to seed to furnish future crops.

Cultivation

The ground used for the cultivation must be well tilled, whatever is its nature; it must be heavily ploughed and often harrowed. Deep cultivation is of the greatest importance in beet-growing, and it is necessary to loosen the subsoil also. This is accomplished by the subsoiler which follows immediately after the plough. Steam ploughs and other mechanical devices are largely employed in beet cultivation, which is thus carried on more cheaply than that of the sugar-cane. The soil must be carefully cleared from weeds, which by their growth would prevent the development of the young beets. This tilling of the soil must be begun immediately after the preceding harvest has been gathered.

The beet is propagated from seed. Some farmers buy the seed, others obtain it

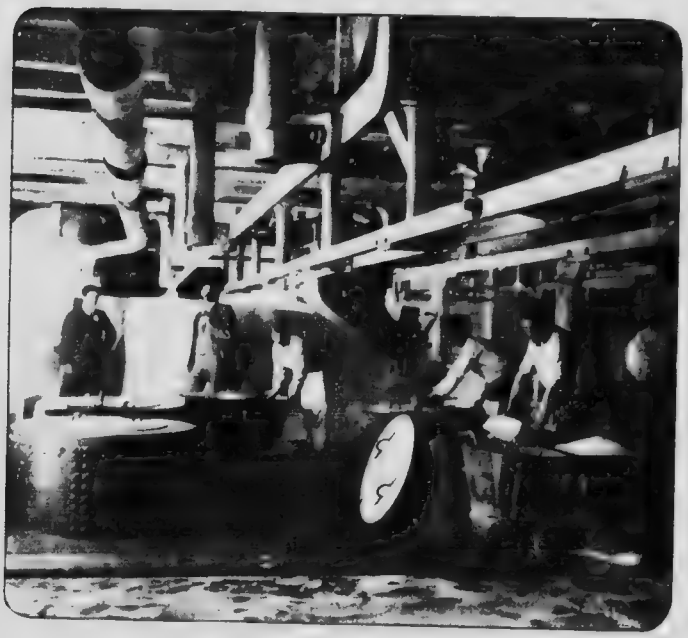


TRANSPORTING BEETROOT PULP

from their own plants. For this purpose the finest beets of former years are laid aside, namely those which possess the desired qualities to the greatest degree. They are stripped of their leaves, however, without the upper part of the root being touched. After the beets have been kept under sand during the winter they are planted in the spring so that they attain full development and bear fruit, from which the seed is obtained. The mode of selection of sugar-beets is described in detail below.

The sowing takes place in March. As a rule sowing-machines are used, which cut light furrows in the soil, about one foot apart, into which the seed is put automatically.

The young plants appear within a short time, and the field is lined with pale-green stripes. Then the field is weeded for the first time by hand. In the North of France, Germany, Belgium, and Holland, labourers, who earn their bread by this kind of work only, take charge of the beet-fields until the harvest. Men, women, and children — all the members of the often large family — handle the hoe with extraordinary dexterity. A few weeks later the field is cleared of weeds for the second time, and as the plants are now stronger and the leaves are more numerous and larger, harrows drawn by horses are often used, performing the work much quicker than hand labour.



CENTRIFUGAL MACHINES IN A SUGAR REFINERY

Then comes the thinning — an operation executed with small hoes (machines cannot be used for the purpose). The labourers' purpose is to kill some of the young shoots without pulling them out, in such a way that there is a distance of about 7 or 10 inches between the remaining plants. Formerly this distance was larger, as then the farmers wanted to grow beets with very bulky roots, but the roots of the varieties grown nowadays contain just as much sugar although considerably smaller. After the thinning the remaining plants are left to grow. The field is only weeded now and then, and when the roots have attained a certain development earth is once or twice drawn up so as to cover the upper parts of the roots which are sticking out above the ground. It has been ascertained after repeated experiments that the influence of the daylight is injurious to the development of sugar in the roots. Gradually the roots grow larger and the percentage of sugar they contain increases.

According to the region where they are grown the harvest ranges from September to the latter days of November. Of course the best time is when the sugar has reached its maximum. But it is not always practicable to wait for this, as the percentage of sugar often increases even during the winter. Hence the time of gathering the harvest is often determined by the requirements of the sugar industry.

As soon as the right moment has come, the field is broken up with ploughs and the plant

are pulled out: the roots are topped, *i.e.*, the leaves are cut off from the roots, so that the latter cannot go on living in the store-houses where they are kept, as this would exhaust all the sugar which has been stored up in them. The leaves are left lying on the field to serve as manure; or, in years when fodder is scarce they are given to the cattle to eat, although their nutritive value is very small.

Ploughs are not always used to break up the soil. Very ingeniously constructed machines exist, which pick out the plants, cut off the leaves, and drop the roots at the side ready for removal to the factory or storehouse. All this is done quite gently, for if the roots are pulled roughly they would be damaged, and then they would be likely to rot.

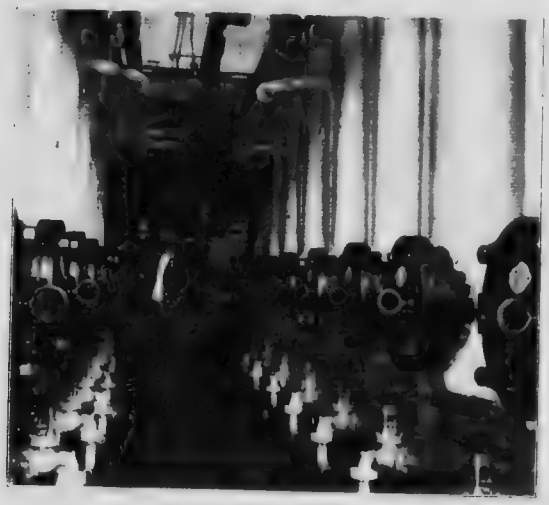
The beetroots are made into heaps near the roadside and covered with leaves to protect them from the cold. Then they are taken in carts straight to the factories, or to the railway-stations or landing-places, whence they are transported to the factories. As, however, the cultivation of beets is practised on a very large scale and the produce is considerable, all the roots cannot be used at once. Stores must be kept in reserve, from which quantities are drawn according as they are wanted. Sometimes the beetroots are kept in siloes built of stone, and sometimes they are piled up in heaps, covering a large surface, and covered with straw and earth exactly as other root crops are commonly stored in the field. The results of this system of preservation are so excellent, that nowadays it is practised almost everywhere.

Manufacture of Sugar

In the early days of beet-sugar manufacture efforts were made to extract the sugar by pressure with such modifications as were demanded owing to the great difference in character between the comparatively hard, fibrous sugar-cane, and the soft, fleshy beetroot. Ordinary crushing between rollers was of no use, so the roots were rasped to a pulp much as is



Interior of laboratory for testing beetroots for seed-selection purposes



IN A SUGAR REFINERY
Charcoal Filters for Clarification of Sugar

practised in the preparation of starch from cassava, arrowroot, potatoes, etc. The soft pulp so obtained was squeezed either by placing it first in small, strong sacks and submitting it to hydraulic pressure, or by passing the pulp through specially designed rollers and afterwards filtering it. None of these methods proved very successful and they were abandoned in favour of extraction by diffusion, which appears to have been first practised in about 1830. This method is now solely used in the beet-sugar industry. We have already discussed the reasons why it is not generally applicable to the sugar-cane, although comparatively recently Mr. Naudet, who has done so much for the beet-sugar, has designed a method which is being employed very successfully in several parts of the world.

From the field direct, or these storing-places or siloes, the roots are conveyed in carts to the factory, where they pass through an elaborate series of mechanical and chemical processes. In the factory the root first comes in a complex of tubes through which a powerful stream of water flows; the root turns and revolves in all directions and on its way leaves behind part of the earth, which still sticks to it, notwithstanding the scraping of the gatherers or of the forward harvesting-machines. The root is carried along to the washer, a machine whose arms, provided with hard pieces of wood, shake it, rub it, and knock it about, while particles of sand and stones which have possibly been carried with it fall to the bottom. Then the beetroot rolls into the cylindrical chest of the cutting-machine, the bottom of which, consisting of curved knives in rapid revolving motion, cut it up into small rectangular pieces or into thin slices. These escape through the openings between the curves of the knives and fall into the diffusing pans through a tube, which turns on its axis and is fastened to the back part of the cutting machine, in such a way that it can distribute the uninterrupted supply of pieces of beetroot over the diffusing pans, arranged next to one another and together forming what is called a battery. As a rule a battery consists of ten or twelve diffusing pans. On the first day of the campaign each pan receives its supply of pieces. The pans are numbered from one to ten or twelve. No. 1 is at the head of the battery and No. 10 or 12 brings up the rear. A certain quantity of water is poured into No. 1, heated by steam, in which part of the sugar contained in the pieces of beetroot is dissolved; then by means of an ingenious system of taps the water flows on to No. 2, in which there are fresh pieces of beetroot, consequently containing more sugar than those in No. 1, from which the sugar has already been partly extracted. In this way the liquid becomes sweeter and flows on to No. 3 and so on, its percentage of sugar always increasing at the cost of the pieces of beetroot. As the water supply continues to flow, the contents of the first diffusing pan are exhausted first: the pieces do not contain any more sugar, the mass has become pulp and falls into a separate division, after which all the water is squeezed out in powerful presses.

After the pulp has been discharged the first division of the battery is filled again with fresh pieces of beetroot and now becomes the last of the series, while No. 2 takes the lead. So each diffusing pan in its turn is the first and the last, the first when the pieces of beetroot are nearly exhausted, the last when they have received a fresh supply. The diffusion process is so efficient that it extracts about ninety-seven per cent. of the total sugar in the beetroots.

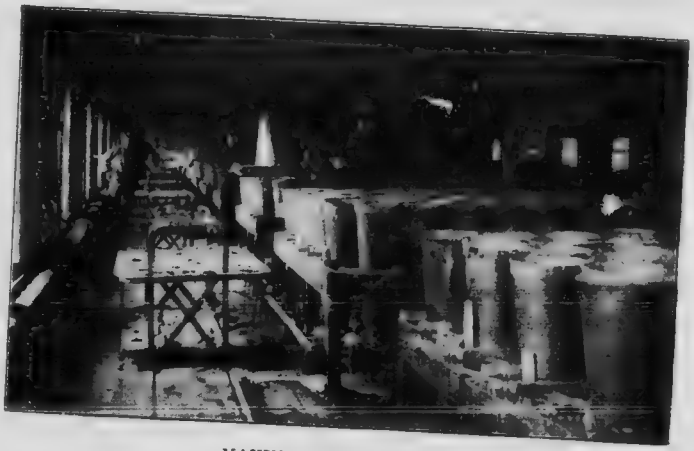
Purification of the Juice. The juice of the beetroot as it leaves the diffusion battery is a turbid liquid of a deep purple or violet colour, with a peculiar taste and smell. As in the case of sugar-cane raw juice it contains two groups of impurities: (1) those which are solid and can be removed by filtering, (2) those which are in solution and accordingly cannot be got rid of by filtering until they have been rendered insoluble by appropriate chemical methods. The proportion of sucrose in the two liquids is about the same, some fourteen to fifteen per cent. but in the beet juice there is a higher percentage of impurities to be got rid of.

Defecation with lime was the first method employed. This has already been described and need not be more than referred to here. It has been generally abandoned as a good method of purifying beet juice. Other means were also adopted but have all given place to what is known as "carbonatation." It was the discovery of the carbonatation process which rendered possible the use of diffusion, because defecation with lime, although successful with the juice obtained by rasping and pressing beetroots, was not found useful with the juice resulting from the diffusion process. The process usually employed now is that known as double carbonatation. The juice is treated with an excess of lime and heated as in ordinary defecation. Carbonic acid gas, generated by roasting chalk or limestone in kilns, is passed into the liquid, combines with the excess of lime to re-form chalk which, being insoluble, renders the liquid cloudy, and afterwards settles as a deposit. Too much carbonic acid gas, however, must not be added or another compound is formed which is soluble again, and undoes the good already accomplished. At the proper moment, therefore, the introduction of carbonic acid gas is stopped, the chalk, etc., allowed to settle, and the clear liquid drawn off, and, if necessary, filtered. The juice is now again treated with carbonic acid gas. It is kept hot during the carbonatation processes and also heated again previous to being filtered.

The syrup is forced through filters under a certain pressure, when it leaves behind the so-called purifying scum, which forms flat cakes between the sieves of the filters. Afterwards cakes fall into a separate pit and are used as manure.

Though the syrup is fairly consistent when it has been filtered, it does not contain a sufficiently high percentage of sugar: there is too much water in it, and concentration is necessary. A peculiar machine is used for the purpose, characteristically called "*appareil à triple effet*," or more generally known as a "triple effect," the principle of which has already been explained under sugar-cane manufacture. It consists essentially of three kettles, which can be heated at low pressure, and through which the liquor successively flows, evaporating more and more.

Boiling. Beetroot juice contains comparatively speaking large quantities of mineral substances, or ash, in solution. These are not all removed by the carbonatation process, but as the liquor is evaporated in the triple effect and the water is got rid of they are thrown out of solution simply because enough water is no longer present to dissolve them. Before the final process of concentration in the vacuum pan can be proceeded



MAKING SUGAR LOAVES

with a further filtration is necessary. This having been accomplished the clear syrup is passed on to the vacuum pan. The subsequent stages are similar to those described for cane-sugar, for it must be remembered that most of the improvements of this kind were originally invented for the beet industry, and later adopted by sugar-cane planters. The boiling is continued until the small sugar crystals are ready to appear, the graining is then encouraged, and the crystals carefully nursed by the addition of more syrup by degrees, so that they develop whilst the mass is kept boiling. At the proper stage the mixture of crystals and liquor—the *masse-cuite*—is run out and is ready to be separated into its two constituents—sugar crystals and molasses.

In order to separate the sugar from this thick syrup, the *masse-cuite* is subjected to the action of centrifugal machines. The centrifugal machine separates the sugar crystals from the treacle, the latter flowing away. The treacle is re-boiled, undergoes a second and third treatment in the centrifugal machine, sugar crystals being separated from it each time. After this it still contains sugar and also a large quantity of impurities, and is called final molasses or treacle. It is possible to extract more sugar from it by chemical processes, but these processes are expensive, and the product thus obtained has but small value, so that the molasses is often drawn off and used for the manufacture of alcohol or in other ways.



DRYING SUGAR LOAVES

BY-PRODUCTS OF BEET-SUGAR MANUFACTURE

These comprise (1) the pieces of roots (pressed into pulp) from which the sugar has been extracted, (2) the filter cake separated at the conclusion of the carbonatation, and (3) molasses, yielding alcohol and potash salts.

Pulp

The remains of the roots correspond to the megass of the sugar-cane, that is to say, they are the residual vegetative matter of the plant from which the sugar-containing sap has been extracted. In its original form it is saturated with water and of no value. Special machinery is, however, employed, and the material is pressed into a pulp, which contains some eight per cent. of carbohydrates, *i.e.*, sugar, cellulose, and other substances, about one per cent. of nitrogenous albuminoids, some mineral constituents, and a small proportion of fat, the remaining ninety per cent. being water. This pulp is returned free usually to the farmers who cultivate the beets, and is extensively employed as a cattle food. The farmer receives as pulp about one quarter the weight of the topped roots he delivers to the factory, and the value to him of this by-product is considerable. One of the illustrations shows pulp being delivered from a factory into a barge.

Filter Cake

When lime has been added, and later on carbonic acid gas, and the liquor has been filtered there remains in the filters a residue consisting of organic matter and large quantities of mineral substances, especially lime. This also is returned to the beet farmers, and is of value as manure.



GATHERING MAPLE SAP



By permission of the Canadian Government

AN AVENUE OF MANITOBA MAPLE TREES, EXPERIMENTAL FARM, BRANDON

Molasses

Beet-sugar molasses are of but little value in their original form. As in the case of raw beet-sugar the impurities of the beet are unpleasant and beet molasses cannot be used as cane molasses can, as an article for confectionery purposes. Beet molasses, however, by undergoing fermentation and subsequent distillation, give rise to alcohol, and on the continent of Europe this is a most important by-product, affording a large supply of alcohol for industrial purposes.

Improvement of the Sugar-Beet

The improvement of the beetroot as a sugar-producing plant is inseparably associated with the name of Vilmorin, the pioneer work having been accomplished by the house of Vilmorin, of Paris. The original races of beet only contained some six per cent. of crystallisable sugar or sucrose. Vilmorin cultivated races of beet in which he increased the sugar contents about eighteen per cent. To attain this the plants were set much closer together and much smaller roots resulted, the total yield of sugar per acre being greater owing to their superior richness in sugar.

The mode of operation is very interesting, and presents one of the best cases the world affords of the improvement of a commercial plant. Passing over the earlier rougher methods, a way was found by which pieces were tested of actual roots which in the following year were set to grow again and produce seed. A field of beetroots is carefully gone over, and plants selected which are of good shape, size, and possessed of other desirable characters. From each of these a small piece is removed with an instrument—not unlike the little scoops used in tasting cheeses. The juice from each little piece is separately expressed, its quantity ascertained, and also the percentage of sugar it contains. The roots are in no way injured and the individual roots with the highest sugar contents after being carefully stored for the winter are planted out and allowed to flower and fruit. The seeds from these selected plants are then employed to raise future crops. Work on these lines is actively pursued to-day in Europe and the United States.

MAPLE-SUGAR

As in the East the sugar-yielding palms have been made use of by man from time immemorial, so in the West, in Canada and the United States, the Indians from similarly remote times have utilised the sugar maples, which find their home in these countries. The sugar was first made in a very primitive manner, but later, with advances in communication and interchange of products between one country and another, cane-sugar from the West Indies appeared as a competitor with maple-sugar in America. At first cane-sugar was a luxury, but as it decreased in price it gradually supplanted maple-sugar, and but for certain qualities the latter product might have died. At the present time cane and beet-sugar have displaced maple-sugar for all ordinary purposes; but owing to its peculiar flavour there is a special demand for it. The most important maple is the "Sugar Maple" and a variety known as the "Black Maple." Of less value are the "Silver Maple," the "Red Maple," and least of all the Box Elder. The sugar maple is confined to the western portions of the United States and the South West of Canada; but, although occurring over a large area of country the commercial production of sugar is restricted to those places where there is a gradual spring, with sunny days and cold frosty nights, as it is only under such conditions that the sap flows sufficiently freely. The actual flow of sap depends on many causes, such as the size of the tree, the season, the difference in temperature between day and night, while even individual trees vary greatly in different years. Trees with large crowns of foliage yield the best sap.

The usual sugar-making season extends from about the middle of March to near the end of April. The mode of tapping the trees is very simple. The bark is cleaned with a brush, and a hole about half an inch across and one inch deep bored in the trunk on the sunny side of the tree. Into this hole a metal or wooden spout is fastened, and to it a pail is attached to collect the sap (see illustration). Periodically the pails are emptied and the contents evaporated down over a fire, until it is in the condition of syrup. This is either retained in this state or evaporation is continued still further, until by testing it is found that the sugar will crystallise out, when the syrup is poured into moulds and allowed to set.

CACAO OR COCOA

It is convenient in many ways to use the name cacao as it tends to obviate the confusion which so often exists due to the wrong usage of the word cocoa. A hazy notion often exists that the cocoa-nut and the beverage cocoa have something in common in their origin. Nothing, of course, could be farther from the truth. The cocoa-nut, or as it is preferable to write it, coco-nut, is the fruit of a palm (*Cocos nucifera*), whilst cocoa is prepared from the seeds of a quite distinct tree (*Theobroma Cacao*). The coca plant from which the drug cocaine is obtained is, needless to say, quite distinct from both.



CUTTING OFF THE FRUIT WITH KNIVES

The high esteem in which cacao was held when it was first discovered is well



JAVA. DIGGING OUT CANAL TO PROVIDE A PLANTATION WITH WATER

indicated by the scientific name given to the genus of plants of which it is the most important member. Theobroma was derived by Linnæus from the Greek words θεος (God) and βρωμα (food) —"Food of the Gods." Belonging to the genus *Theobroma* there are altogether about twelve species, all of which are natives of tropical America.

The commercially important cacao (*Theobroma Cacao*) is a small spreading tree, not usually exceeding twenty feet in height, although trees of double this height have been recorded from time to time. The illustrations afford a good idea of its general habit and also show perfectly clearly one of its most characteristic features, namely, the manner in which the flowers and pods are borne. In the trees of temperate climates, and in the majority of those of the tropics, the flowers and fruits arise on young side branches, for example, in apples, pears, oaks, horse chestnuts, and numberless other instances. In some tropical trees, however, this is not the case, but they are carried directly on the main trunk and principal branches. The cacao affords the best instance of this striking peculiarity amongst important economic plants. A little tuft of a dozen or more small, in fact quite insignificant, flowers appear on the trunk, and are succeeded by the pods, which are often eight or ten inches in length. These have a very odd appearance, hanging quite away from any leaves on the thick trunks, as a glance at the picture on page 115 will show. Various reasons have been put forward to account for this strange habit. It has been supposed that extra support was desired, an idea upheld by the fact that many, although not all, of the fruits so borne are large and heavy. Another view, which has a good deal to support it, is that in the dense tropical forests the trunks are more accessible to butterflies and other insects than the massed foliage, and that flowers borne in the comparatively open region of the stems have more chance of being visited and of setting fruit than they would have if they arose in what is, under other circumstances, the normal position.

De Candolle sums up the question of the native country of this important plant in the following words: "The common cacao (*Theobroma Cacao*) is a small tree wild in the forests

of the Amazon and Orinoco basins and of their tributaries up to four hundred feet of altitude. It is also said to grow wild in Trinidad, which lies near the mouth of the Orinoco. I find no proof that it is indigenous in Guiana, although it seems probable. Many early writers indicate that it was wild and cultivated at the time of the discovery of America from Panama to Guatemala and Campeachy, but from the numerous quotations collected by Sloane it is to be feared that its wild character was not sufficiently verified. It was perhaps introduced into Central America and into the warm regions of Mexico by the Indians before the discovery of America. Cultivation may have naturalised it here and there, as is said to be the case in Jamaica. In support of this hypothesis, it must be observed that Triana indicates the cacao as only cultivated in the warm regions of New Granada, a country situated between Panama and the Orinoco valley. However this may be, the species was grown in Central America and Yucatan at the time of the discovery of America. The seeds were sent into the highlands of Mexico, and were even used as money, so highly were they valued. The custom of drinking chocolate is universal. The name of this excellent drink is Mexican. The Spaniards carried the cacao from Acapulco to the Philippine Isles in 1674 and 1680, where it succeeded wonderfully. It is also cultivated in the Sunda Isles. I imagine it would succeed on the Guinea and Zanzibar coasts, but it is of no use to attempt to grow it in countries which are not very hot and very damp."



CEYLON. FIRST CROP OF COCOA AFTER FIVE YEARS

The forecast of De Candolle, based on his knowledge of the geographical distribution of plants, that the cacao plant would probably thrive on the Guinea coast, has been verified to a degree probably beyond his utmost expectations, in the extraordinary development, as is shown below, of the industry in San Thomé and to a less degree in the Gold Coast Colony and the Cameroons.

CACAO-PRODUCING COUNTRIES OF THE WORLD

The output of cacao for 1904, the last year for which complete statistics are available, in the chief producing countries of the world was as follows according to the *Gordian :—*

America and West Indies. Ecuador .. .. .. 28,433 tons



CEYLON—THE PEELING OF THE FRUIT

America and West Indies. (*continued*)	Brazil	23,160 tons		
	Trinidad	18,574 ,,		
	San Domingo	13,557 ,,		
	Venezuela	13,048 ,,		
	Grenada	6,226 ,,		
	Cuba and Porto Rico ..	3,266 ,,		
	Haiti	2,531 ,,		
	Jamaica	1,650 ,,		
	Martinique and Guadeloupe	1,215 ,,		
	Surinam	854 ,,		
	St. Lucia	800 ,,		
	Dominica	485 ,,		
			113,799	tons
Africa.	San Thomé	20,526 ,,		
	Gold Coast	5,687 ,,		
	Cameroons and Togo ..	1,090 ,,		
	Congo Free State	231 ,,		
			27,534	,,
Asia.	Ceylon	3,254 ,,		
	Dutch East Indies	1,140 ,,		
			4,394	,,
Australasia.	Samoa	19 ,,	19	,,
Other Countries.		806 ,,	806	,,
	Total world's crop		146,552	,,

PICKING THE COCOA PODS, TRINIDAD



VARIETIES OF COCOA
Cacao Criollo
By permission of Messrs. Cadbury Bros.

Cacao is thus pre-eminently a tropical American and West Indian crop, although it is worthy of note that San Thomé is a serious competitor for the first place as a cacao-producing country. In 1903 it held second place, in 1904 it was third, and in 1905 it actually surpassed Ecuador, and attained the premier position.

VARIETIES OF CACAO

An enormous number of varieties of cacao are recognised and distinguished by local names in various parts of the world. The most authoritative modern account, embracing all the world's forms, is that of Dr. Preuss, who has travelled through most of the cacao-producing countries, and spent much time in examining the different races. He finds, however, that it is impossible to set out in a table the differences which distinguish all the varieties, and that those of each country must be considered separately. The chief characteristics used for distinguishing the varieties are the shape, external appearance, and colour of the pods, and the colour of the interior of the beans or seeds



VARIETIES OF COCOA
Cacao Calaba
By permission of Messrs. Cadbury Bros.

A classification of the Trinidad cacaos was drawn up in 1882 by Dr., now Sir, Daniel Morris, K.C.M.G., the Commissioner of Agriculture for the West Indies. From Trinidad cacao was sent to Ceylon, and the Ceylon varieties have recently been the subject of study by Mr. R. H. Lock, and his key to the varieties published in the *Circulars and Agricultural Journal* of the Royal Botanic Gardens, Ceylon, is given below.

This is substantially that originally drawn up by Sir D. Morris, and thus embraces the West Indian and East Indian cultivated forms.



VARIETIES OF COCOA
Cacao Forastero
By permission of Messrs. Cadbury Bros.

The two main groups are Criollo and Forastero.

Criollo Varieties, characterised by plump, pale coloured seeds, contained in a relatively thin-skinned pod, which is usually rough with a pointed apex.

Forastero Varieties include all which are not Criollo: the beans vary in colour from pale to deep purple, the latter being bitter in taste and of poor quality.

A PLANTATION IN SURINAM

Criollo. Beans plump, majority white or pale when cut across. Shell of pod soft and relatively thin.

(1) *Nicaragua.* Beans very large, somewhat flat.

(2) *Old Red.* Beans half as large as (1); more rounded.

Forastero. Majority of beans purple in colour. Shell of pod relatively hard and thick.

(3) *Cundcamor.* Pods sharply pointed, bottle-necked, rough; beans of high quality, pale, rounded.

(4) *Liso.* Pods various, usually not bottle-necked; beans of fair to good quality.

(5) *Amelonado.* Pods ovate, nearly smooth, usually bottle-necked; beans of lower quality, usually flat, and all purple.

(6) *Calabacillo.* Pods ovate, smooth, small, not bottle-necked; beans small, flat, and all deep purple.

The illustrations of Criollo, Forastero, and Calabacillo pods, entire and in section, will serve to render clear some of these characteristics.

Of each of these kinds there is a yellow and red variety, distinguished in naming by the addition of *amarillo* (yellow) or *colorado* (red) to the first name. Thus we have *Forastero*, variety *Cundcamor amarillo*, and *Forastero*, variety *Cundcamor colorado*, and so on.

Mr. J. H. Hart, Superintendent of the Botanic Gardens of Trinidad, whilst agreeing with this classification in the main, regards Calabacillo cacao as a class by itself, and not merely as a variety of Forastero.

The varieties differ also in hardiness. Calabacillo is the most vigorous tree, and will grow under the worst conditions, but its produce is much inferior to the others. Forastero is intermediate in hardiness and value, whilst Criollo is the most delicate tree, and yields the beans of the greatest value. As in the case of the sugar-cane, the distribution of plants from one country to another has resulted in great confusion in the naming, and it is exceedingly difficult to correlate the varieties of different countries.



By permission of *Messrs. Cadbury Bros.*

CEYLON. A HILL CACAO ESTATE

Cultivation

General Conditions. Cacao is not a plant which will thrive under any conditions; on the contrary, it is very exacting, and considerable knowledge of its requirements is necessary in order to choose a proper spot. Deep alluvial soil, well-watered but well drained, in a sheltered

locality are what it likes most, and these must be found for it in a thoroughly tropical climate. Many parts of the West Indies, although quite tropical, and with sufficient rainfall, are absolutely unsuited to cacao. In Barbados, for instance, although sugar-cane, cotton, and other crops which are regarded as distinctly tropical, can be grown all over the island, there are extremely few places suited to cacao. Strong winds are particularly injurious, and Barbados being in the track of the "Trades," it is only in a few sheltered valleys, with other desirable attributes also, that the plant can thrive. Accordingly it is not altogether surprising that amongst the British West Indies we find only Trinidad, Grenada, Jamaica, St. Lucia, and



SURINAM. YOUNG CACAO PLANTS SHADED FROM THE SUN

Dominica figuring in the list of cacao-producing countries. These are all mountainous, well-wooded islands, whilst the more bare and exposed islands such as Barbados, Antigua, etc., are, speaking generally, unfitted for the crop.

Mr. J. H. Hart, referred to before, in his useful book, "Cacao," says: "The ideal spot in which to found a cacao plantation is a well-sheltered vale, covered with large trees, protected by mountain spurs from the prevailing winds, well watered, and yet well drained, with a good depth of alluvial soil on which rests a thick deposit of decayed vegetable matter; easy of access, and in a district distant from lagoons or marshes for the sake of the proprietor's health. Such a spot in a climate similar to that of Trinidad could not fail to produce regular crops of the finest quality of cacao."

Planting. The ground having been cleared of the original forest, planting can be proceeded



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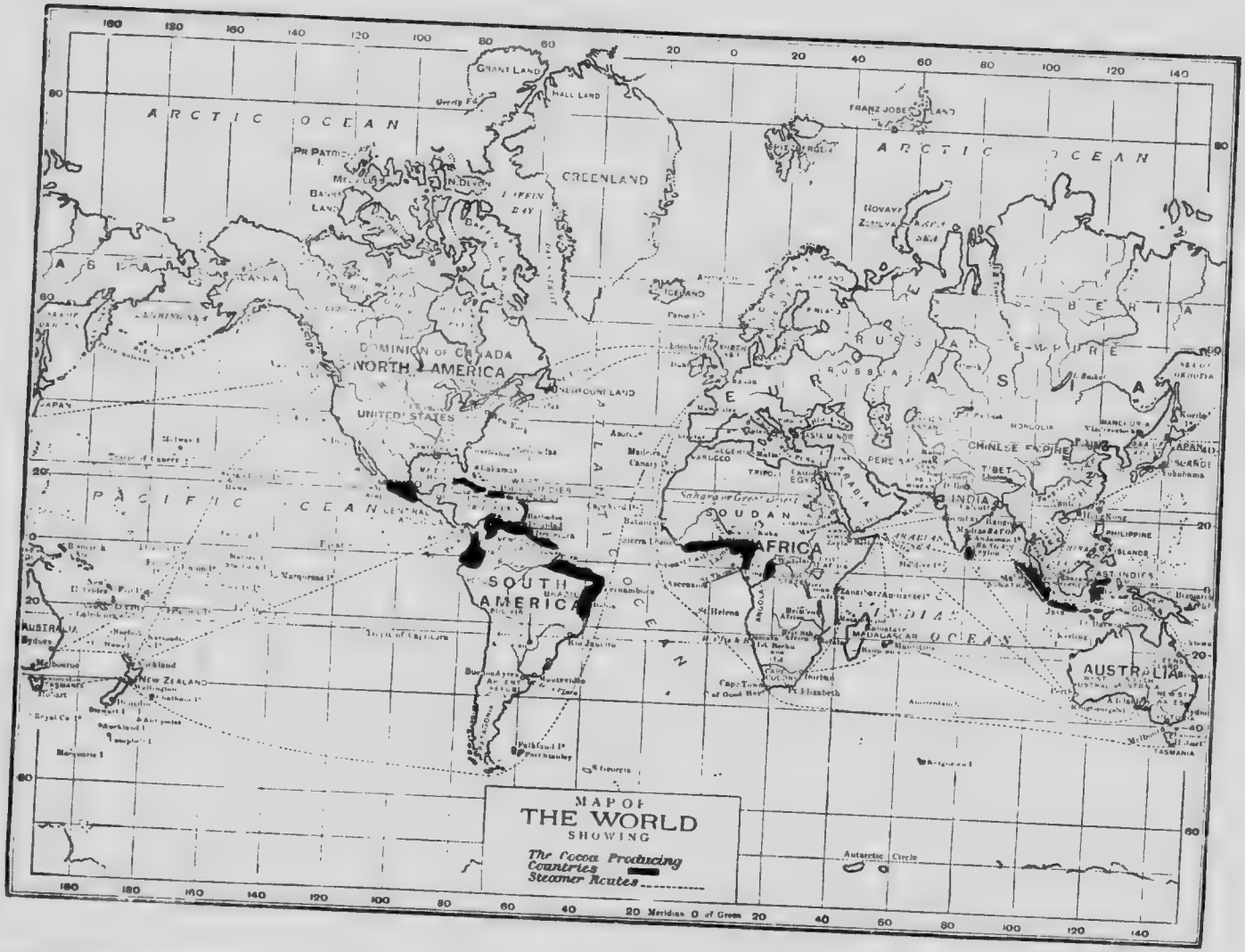
CEYLON. NURSERY OF CACAO SEEDLINGS IN BASKETS OF PLAITED PALM LEAF

with, and two methods may be adopted. The seeds can be sown in nurseries and kept there until young plants a foot or so high are available, or seeds may be sown in the ground, where future trees are desired; the latter method is called "planting at stake." The young plants have to be carefully shaded in either case. In a tropical nursery, bamboos cut up into lengths, each consisting of one joint, form excellent pots, and are extensively employed. Plaited palm-leaves also form useful "flower-pots." The young plants are carefully tended until of sufficient size, and then planted out and carefully shaded from the sun, during a season when they will get showers to give them a good start in life.

When the seed is sown at stake three seeds are planted in one hole; the holes are made at a distance of four to five yards apart in all directions. Many of the seeds will probably not germinate, however, owing to various causes, but of the plants which do come up the weaker ones are pulled out for the benefit of the stronger specimens. When they are a little over three feet high, they are pruned, in order that the trees may attain a pyramidal crown.

Shading. Cacao trees raised from seed, whether in nurseries or in the open, require to be protected from the sun, when placed in their permanent positions. This is usually afforded by growing bananas, pigeon peas, cassava, or other temporary crops between the rows of young plants. They supply the requisite shade, and, moreover, yield crops, and bring in returns during the five or more years of waiting for the cacao to mature. This temporary shading is quite distinct from the use of permanent shade trees. In many countries cacao thrives better under the light shade of taller trees and those nearly always used are various leguminous trees which we may speak of collectively as *Bois immortel* (*Erythrina*, spp.) or *Madre de Cacao* (Mother of Cacao), to use the Spanish name. These are planted at proper distances amongst the young cacao, and kept there permanently even when the cacao is fully grown, when the temporary shade plants have long since been removed.

Fruiting. Trees about five years old bear fruit. These are at first green, turning red and yellow as they ripen and when dried their colour becomes a chestnut-brown. They are attached to the stem or branches by a short stalk, and are somewhat like very thick cucumber


ARCTIC OCEAN
GREENLAND
DOMINION OF CANADA
NORTH AMERICA
UNITED STATES
PACIFIC OCEAN
SOUTH AMERICA
ATLANTIC OCEAN
AFRICA
SOUDAN
RUSSIAN EMPIRE
RUSSIA
SIBERIA
CHINESE EMPIRE
INDIA
INDIAN OCEAN
AUSTRALIA
NEW ZEALAND
MAP OF
THE WORLD
SHOWING
The Cocoa Producing Countries
Steamer Routes
Meridian 0 of Greenwich
Antarctic Circle

in shape, about eight or more inches long, and three or four inches in diameter. The process of blossoming and bearing fruit is completed in about four months, and is continued throughout the whole year; hence fruits may be gathered at any time of the year, although at certain seasons the principal crops are obtained, for example, in the West Indies in December and January, during the early part of the dry season.

Picking. The fruit which is hanging low enough to reach it with the hand is gathered by carefully turning it round until it breaks from the stalk; those which cannot be reached are cut off from the stem and branches by means of a curiously shaped small knife fastened to a long stick. The gathering requires great care, as the buds and blossoms, which are to bring forth the next harvest, are easily injured.

Neither unripe nor over-ripe fruits yield a good product. The picker judges by the colour



CACAO FRUIT

The Beans of two laid bare

whether a fruit is ripe or not: moreover, the ripeness may be ascertained by the accustomed ear by tapping the pod.

The rind of the pod is by nature firm, a little woody, but becomes leathery when dried. Each pod contains some sixty seeds, arranged in five or eight rows (mostly five); the seeds are white when they are fresh, but brown and covered with a fragile skin or shell when dried. These seeds, which are not unlike beans or almonds, are imbedded in a mass of mucilaginous pulp, of a sweet but acid taste. The seeds only require to be extracted, cured and dried, to become the cacao-beans of commerce.

Breaking. The pods are left on the ground by the pickers and collected up by women and children into heaps to be opened. This operation is known as "breaking cacao." The pods are often opened with a cutlass, which should not be too sharp. Care is needed as just to cut through the rind and not injure the seeds. The opened pod is taken and the slimy mass of seeds and pulp scooped out with the fingers, and finally conveyed to the curing house in baskets, sacks, or other convenient means, with or without the aid of mule or donkey carts, according to the nature of the estate and other circumstances.

The empty rinds are left in heaps on the field to rot and help to fertilise the soil. In case of attack by some of the fungoid diseases it is very incautious to leave the pods above ground, as they only form nurseries for the propagation of disease. In these cases the best course is to bury them.

Fermenting. The fermentation of the beans is a very important operation and requires considerable care. The *modus operandi* varies according to the kind of cacao, to the local usages, and to the planter's views. As a rule the wet cacao-beans are put in a sweating-house specially built for the purpose, and divided into small compartments opening on to a common space, by means of movable partitions so that it is readily possible to transfer beans from one compartment to another. The flooring of the house is important unevenness of any kind is to be avoided as rendering the beans liable to damage by being crushed when shovelled from one place to another. Cement, iron, pitchpine or other resin-containing timbers will not do, owing to the acidity of the juice. A good method is to have an upper flooring of laths placed lengthwise to the direction of shovelling. The juice from the beans escapes between the laths onto a water-tight floor below arranged with a central exit drain.

The cacao heaped up in the compartments must be turned every twenty-four hours, in order to cause a regular sweating. If this turning can be done twice a day it is still better, for the looser the beans are lying on one another the more regular the sweating, which destroys the slimy substance which covers the beans. Three days are usually quite long enough to complete the fermentation process.

On some plantations there are no sweating-houses, but the beans are thrown into large



SURINAM. YOUNG CACAO TREES IN THE SHADOW OF BANANA TREES

heaps on the barn-floor to sweat. Another method is to let the cacao-beans ferment in a basket lined with banana leaves.

Fermentation affords the most convenient method of getting rid of the mucilaginous pulp which surrounds the freshly gathered seeds. Internal changes also take place, and the seeds lose to some degree the bitter taste they formerly possessed. The pale-coloured seeds of Criollo cacao become of the nice cinnamon-brown colour so appreciated in the market, whilst the deep purple colouration of Forastero and Calabacillo cacaos is also modified. Another change of some importance is that the skin or shell of the seed becomes tougher and so facilitates the subsequent handling, and helps to preserve the contents from the inroads of fungi. In some countries fermentation is not practised, but fermented cacaos fetch better prices in the market than the unfermented product.



SHADED CACAO TREES

Washing. Opinions differ as to the advisability of washing the beans after they have been fermented. It is generally practised in Ceylon, in the Cameroons, and elsewhere, but not so in the West Indies, for instance, in Trinidad. Amongst the advantages claimed are that it readily removes the remaining portions of the pulp and allows the beans to dry more rapidly. Planters who do not favour the practice appear to think that the method involves more trouble than the increase, if any, in the price warrants.

Drying. Whether the beans have been washed or not they have to be dried. The methods of drying cacao practised in different countries or by individual planters in the same country vary considerably. They may, however, be resolved into two groups, according to whether the heat of the sun is relied on or whether artificial heat is resorted to.

With a very small crop, such as a peasant proprietor would obtain from a few trees, the beans can be spread out on the ground or on a tray or piece of matting or cloth, which can readily be picked up and placed under cover should it rain. For a large crop this is impossible unless the seasons are so regular, as, of course, they often are in parts of the tropics, that continued fine weather can be relied on.

A great advance on this method is to spread the beans out in a thin layer on large platforms

mounted on wheels, which run on rails. There is a house adjoining, and each fine morning the platforms with their loads are run out, and can be hurried under cover in a very few minutes if necessary. The heat of the mid-day sun is sometimes so great that it would not be wise to allow the cacao to remain exposed the whole day.

The alternative method is to make the platform stationary and have a movable roof. This is the method generally adopted in Trinidad, although the former is also largely employed. A drying-house of this character is shown in a picture in the next part.

Economy of space can often be effected by combining the two methods. We may have a fixed platform sufficiently raised to allow one, two, or more tiers of movable trays to be protected under it, whilst a sliding roof, in one or two portions, can be used to cover the fixed platform at will. Such an arrangement, in use on one of Messrs. Cadbury's estates in Grenada, is shown in the illustration on p. 128.

Artificial drying-houses are of various types. One of the most successful may be called the Ceylon drier, and a house of this pattern was some years ago built by the Imperial Department of Agriculture for the West Indies at the Botanic Station, Dominica. Hot air is made to pass in succession over and around a series of trays, arranged one above the other, and in such a house cacao can be dried in twenty-four hours, instead of requiring a week or so as when dried in the sun.

Another pattern of drying apparatus which has recently attracted considerable attention in the West Indies is that patented by Mr. Hoadley, of Chaguanas Estate, Trinidad. The following description of his invention is taken from the *West Indian Bulletin*, Vol. VI (1906), p. 80: "The cacao-drying apparatus consists of an ordinary room, thirty-four feet square, with twenty-five feet perforated circular drying floor, upon which cacao is placed direct from the fermenting box. In the centre of the drying tray is a vertical axle from which project four arms which are revolved once in ten minutes. To each arm are attached six ploughs, the operations of which are equal to the work of twelve coolies in keeping the cacao in constant motion. Hot air is generated by exhaust steam which is passed into 1,100 feet of piping enclosed in a box, over which cold air is drawn by a powerful fan which makes from 600 to 700 revolutions per minute. The air in its passage becomes heated to any desired point up to 150° F., and is forced up through the drying floor. The machine will dry from twelve to fifteen bags of cacao in thirty to thirty-six hours. The cost of installing the system is said to be between £300 and £400." A Trinidad bag of cacao weighs about 170 lbs.

Colouring. Cacao beans are appreciated of a good colour and of bright clean appearance. Sometimes uniform colouration is secured by mixing with the beans a small amount of red earth or clay, or even annatto. This, however, is by no means a universal practice.

Polishing. During damp weather the cacao if left in a heap tends to become mildewed on the outside. This can be prevented or got rid of by the gentle rubbing of the beans against one another,



GATHERING THE FRUIT

and frequently such rubbing also serves a useful purpose in finally cleaning the beans, and removing the last traces of adherent pulp. This is particularly so in places where washing is not resorted to. A simple method of obtaining these desirable results is that known as "dancing cacao," an illustration of which is given on p. 130. A heap of beans on a drying floor is shown, and in the middle are a number of men engaged in treading the produce with their naked feet. The three men at the sides with shovels keep returning to the centre the cacao which during the operation naturally tends to become more and more spread out. The result is to remove mildew, etc., and to give a final polishing to the beans. Dancing is comparatively expensive, and in Mr. Hoadley's apparatus described above there is an additional machine which clays and polishes the beans, or merely polishes them according to special requirements, and thus does away with this process of "dancing."



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GRENADA, B.W.I. SAMARITAN ESTATE

Packing and Shipment. The cacao is now ready to be shipped. It is most important that it is thoroughly dry, beyond that no special care is requisite. The beans are put into bags, or sometimes barrels, and can at once be placed on board ship.

In Europe Hamburg is now by far the most important port for cacao, a position which it attained in 1904, previous to which Havre had occupied the first place. London occupies the third position. The other great port of the world for the reception of cacao is New York, which yearly increases its import of this crop, and is now about equal to Havre, and receives annually nearly twice as much cacao as London does.

CACAO AS A FOOD-STUFF

Before entering on a description of the processes through which the raw cacao-bean of commerce passes before it reaches the consumer either as cocoa powder, chocolate, or in other forms, it will be advisable to note the composition of the beans, as then we shall be in a position to understand better the mode of manufacture.



CACAO FLOWERS AND FRUIT

The contents of the cacao-beans are just as in other seeds the food-reserve the mother-plant has put by for the young plants to live until they are able to subsist by themselves. The seeds of the cacao plant contain albuminoids or nitrogenous substances, starch, water, fat, sugar, cellulose and mineral matter; also the alkaloid theobromine, and a colouring matter called cacao-red.

According to Payen the average composition of good West Indian beans is as follows:—

Fat (cacao-butter)	500 per cent.
Starch	100 "
Albuminoids	200 "
Water	120 "
Cellulose	20 "
Mineral matter	40 "
Theobromine	20 "
	1000

On account of the high percentage of nitrogenous materials, fat and starch, which it contains, the nutritive value of cacao is great, and the alkaloid theobromine gives it stimulating properties also. This stimulating effect of cacao is increased by the volatile oil developed during the process of roasting, and to which cacao owes its characteristic aroma.

It will have been noticed that the bean contains approximately half its weight of fat (known when extracted as cacao-butter). This, with the other constituents, renders the beans very



TURNING THE BEANS

nutrition but too fatty to suit many people's taste. One of the first operations in the preparation of cacao is to get rid of the greater portion of this fat. It is not that the fat is harmful or indigestible but simply that there is too much of it for ordinary purposes.

The fat may be separated from the beans in two ways. In factories it is effected by means of hydraulic presses, and an important by-product is obtained, worth about double the market value of the original weight of the raw beans. In this way only a portion of the contained fat is extracted from the beans, but by chemical processes it is possible to extract it all. By boiling, steaming with water or by grinding the beans to powder and treating them with ether or carbon bisulphide, the whole of the fat can be removed.



DANCING " CACAO BEANS IN TRINIDAD

One method of lessening the proportion of fat is by adding starch, but whilst the fat is relatively reduced in this way, the percentage of the other useful constituents of the cacao is reduced also, with loss of its agreeable fragrance and stimulating properties.

A Dutchman, Mr. C. J. van Houten, of Amsterdam (1801-1887), the founder of the well-known firm bearing his name, endeavoured to solve this question of the excess of fat and after long searching he succeeded in not only freeing the beans from the superabundant fat, but also in giving such a form to the mass which remained after the process that the cacao retained all its nutritive power, and could be easily made into an agreeable beverage.

At first he called his product chocolate-powder, a name which was soon changed into Van Houten's cocoa—to indicate that the product only contained the pure elements of the cacao beans, and was not mixed with starch or any other added substance.

CEYLON. SIFTING THE BEANS IN A BARN

We are accustomed to call cacao soluble nowadays because it apparently dissolves in hot water or milk; however, soluble is the wrong word to use, as there is no solution in the ordinary sense as, for instance, in speaking of sugar or salt being soluble in water or milk. In reality the discoverer, Mr. C. J. van Houten's purpose was to prepare a powder which should be completely miscible in liquids. It is a sign of complete diffusion that the cacao after boiling water has been poured on it forms hardly any sediment at the bottom of the cup.



SURINAM. A SWEATING BARN (EXTERIOR)

Cacao or cocoa butter, the extraction of which is described elsewhere, is, when quite pure, a white, rather hard fat, with an agreeable odour of chocolate, and a delicate taste. It melts slowly in the mouth. Its melting-point is about 85 to 90° F., and its specific gravity varies between 0·85 and 0·98. It is only slightly soluble in warm alcohol, but may be completely dissolved in ether. Cacao-butter does not turn rancid if carefully stored, which property renders it very valuable for pharmaceutical and other preparations. When fresh it is yellowish-white, but becomes quite white on keeping.

Cacao-butter is frequently used in the preparation of perfumes and cosmetics. The fresh butter is used in ointments, cerates, and plasters. Moreover, cacao-butter is a constituent of almost all pomades, and consisting of stearin, palmitin, and olein, it makes an excellent soft toilet soap, of a beautiful white colour, when mixed with certain alkalies. The so-called "chocolate fats" are frequently derived from coco-nut oil and palm oil, and are used to adulterate cacao-butter, being much cheaper.



SURINAM. A SWEATING BARN (INTERIOR)

It is to the cacao-red and the volatile oils that the beans owe their colour, peculiar aroma, and to a great degree their characteristic taste. The amount of theobromine contained is comparatively small and yet to it cacao owes its stimulating action. In 1840



CARRYING THE BEANS TO THE BARN

Wosscressenzky succeeded in separating the alkaloid theobromine from the beans; he found that chemically it differed little from caffeine and theine, the active principles of coffee and tea, whence it is that the physiologically stimulating effect of cacao, coffee, and tea is very similar.

Those substances which are known in chemistry under the name of alkaloids are often very poisonous. Theine, caffeine, and theobromine act as poisons when they are consumed in large quantities.

Chocolate is a mixture of cacao with sugar, and as a rule with spices also. Usually one part of cacao is mixed with one part (or 1½ part at most) of sugar. Cheap chocolate often contains admixtures of starch, such as corn flour, wheat, rice, or potato starch, etc.; powdered roasted acorns, chestnuts, earthnuts, chicory, ship biscuits, the ground shells of the beans and other woody substances, and even plaster have been employed as adulterants. In England some brands of cacao contain starch, but this fact is, or should be, stated on the tin, so that it loses the character of adulteration, and, moreover, the price is lowered in proportion. The cacao of some of the most important factories in Holland has been found to contain twenty-nine to thirty per cent. of fat, fourteen to eighteen per cent. of albuminoids, five to nine per cent. of ash, four to five per cent. of water, 0·6 to 1·5 per cent. of theobromine, the rest consisting of starch. Thus it is seen that the composition varies, but these figures may be taken as the limits which "pure" cacao-powder may not exceed.

In the preparation of medicines chocolate is often used to disguise the taste of disagreeable drugs. Thus, chocolate is sometimes mixed with quinine, rhubarb, steel preparations, magnesia, calomel, ipecacuanha, santonin (the well-known worm-cakes for children, which are still manufactured in large quantities in some Dutch factories to be exported to China, where children seem to be very much plagued with ascarids), castor-oil, etc., and tabloids or cakes are made of these mixtures, containing certain quantities of these drugs.



STONE DRYING FLOOR WITH MOVEABLE ROOF

THE MANUFACTURE OF CACAO AND CHOCOLATE

Until the latter part of the eighteenth century the fabrication of chocolate was chiefly effected by manual labour, the beans being pounded to powder in an iron mortar. Even to this day, the Chinese cook in the Philippine Islands, who makes the cacao-beans which are grown there into chocolate, carries his whole factory about with him. This consists of a small wooden table, made to rest on the knees of the man, who squats down, and on this table the shelled beans are pounded in a small marble mortar with a heated pestle, and the mass is kneaded to chocolate-dough with sugar, pepper and other favourite spices.

With the exception of such cases as the latter, manual labour has been replaced as a rule by wonderful machines; the first of which was put into practice in 1778 by M. Doret, of the medical faculty of Paris. These machines have been altered and improved continually, though the purpose which the engineers have in view always remains the same, namely, to grind the beans to a powder of the greatest possible fineness, and to mix it as intimately as possible with substances such as sugar and flavouring materials.

Whether a chocolate-factory is large or small, the cacao-beans always have to undergo the same essential processes. These chief stages are as follows:—(1) Sorting and cleaning the raw beans. (2) Roasting the cleaned beans. (3) Breaking and shelling the roasted beans. (4) Grinding of the roasted and broken beans and the addition of other substances such as sugar, spices, etc. If cocoa is being made the fat is extracted at this stage. (5) Moulding and packing.

Sorting and Cleaning the Raw Beans

The cleaning and sorting of the raw beans is of the greatest importance. The principa

object in cleaning and sorting the beans is to get rid of all foreign substances, such as sand, pieces of stone, etc., which later on might damage the rollers of the grinding-machine. Impurities also spoil the aroma of the cocoa when it is roasted and lower its solubility.

The beans are cleaned by placing them in long barrel-shaped sieves which are made to rotate slowly. The meshes of the sieve must be of such a size that everything smaller than cacao-beans themselves can pass through. At the same time a draught created by powerful fans carries away dust. The sieves are so made that the beans are at the same time sorted into three groups large, medium, and small. The material to be roasted thus consists of beans of equal size, which is of advantage because if beans of unequal size were roasted together the small ones would spoil by the time the large beans were sufficiently roasted.

Roasting the Beans

The beans are next exposed to a high temperature, that is to say, they are roasted. This roasting serves several purposes. First of all the aroma of the beans is increased and the starch is partially changed into dextrin, a substance which is more soluble in water than starch. The bitter substances which the beans contain are partly eliminated, the shells become dry and crisp, and the beans themselves dry, which renders them more easily ground. The flavour of the beans is greatly improved by the roasting.

The roasting is carried out in large iron drums, each of which may hold a ton or more of beans. Coke fires, gas, or better, superheated steam are employed, and great care and judgment are necessary to obtain the best results. The temperature for roasting cacao-beans is not so high as that for roasting coffee; experience has shown that the best temperature lies between 260° and 280° F. The beans should not be left too long in the machine, and they are turned continually. The iron boxes are accordingly made to revolve. The temperature in the boxes is carefully regulated, although it must by no means be constant throughout the whole process. The time required for roasting depends on the quantity of beans roasted at once and on the kind of beans. Therefore, the roaster should always be a reliable and experienced person. To prevent too great a loss of aroma and to cause the beans to be shelled more easily, they are cooled suddenly after the roasting is completed.

Breaking and Shelling the Beans

The roasted beans are now "broken down" and the shells removed. The beans are gently cracked and exposed to a powerful air-blast which can be regulated according to the coarseness or the fineness of the fragments; a gentle wind is made to blow when the beans are broken into very small pieces, and a more violent one when the pieces are bigger, so that the separation of the particles of beans from the larger, but specifically lighter, shells is effected with great accuracy.



STONE FLOOR FOR DRYING CACAO-BEANS IN THE OPEN AIR

For the preparation of chocolate it is important to sift the broken beans once more, in order to get out the harder germs, the powder of which leaves a sediment in

the beverage. This is done mechanically by means of a very ingenious machine invented by the firm of J. M. Lehmann, of Dresden.

The shells of the cacao-beans form the only waste product in cacao industry. As the shells form about twelve per cent. of the beans, it is desirable to find a use for them. Cheap chocolate often contains the ground shells, but for the better kinds they are useless, as they may rightly be said to be adulterants, although it is true that they contain some theobromine and some fat, and taste like cocoa. The ground shells are sometimes sold as "cocoa-tea," and find purchasers, especially in Ireland. As an article of commerce the shells are called



ROASTING CACAO IN VAN HOUTEN'S FACTORY

"miserables" in England. They may be made more palatable by candying them with sugar, and in that state they are a favourite kind of sweetmeat for children, especially in the east of Germany. By treating them with benzine it is possible to extract the fat they contain, which is sold under the name of second Dutch cacao-butter; however, the value is but small. These different uses consume but comparatively small quantities of the supply. Infusions of the shells of cacao-beans are sometimes employed to improve the taste of coffee-beans during roasting, and also to enhance the flavour of coffee-substitutes made out of corn or malt. Cacao-extracts are also made out of the shells, by boiling them with water; the extract thus obtained is reduced by evaporation until it acquires a certain strength. This extract is not only used as a substitute for coffee and tea, but is also sometimes mixed with cacao and chocolate.

SEND GAS ENGINE IN MESSRS. CARRETT'S FACTORY



THE PACKING ROOM, BOURNVILLE

It was ascertained by experiments that the nutritive value of these shells is about the same as that of middling hay. Cattle soon get to like them, and experiments made with three groups of milch-cows were successful. After they had been fed with the new fodder for ten days the analysis of the milk showed an increase of butter and milk sugar; and, moreover, an increase in the quantity of milk. In a report on the "Experimental Farms of Canada, 1898," the usefulness of cacao-shells as manure is pointed out.

Grinding

Formerly the beans, after having been roasted and broken, were ground several times before they were taken to the "melangeur" or mixing-machine, in which the mass was rubbed still finer and mixed with sugar. Machines with millstones or rollers are now used in which the cacao is ground to a liquid or thin paste owing to the heat developed by friction. One advantage of the reduction to the liquid state is that the sugar mixes much more easily with the cacao, and that an intimate infusion is more readily effected.

This fusion is accomplished most successfully when the temperature is constantly kept at the same level, a little above the melting-point of cacao-butter, *i.e.*, between 85° and 90° F. for this reason a mixing-machine is always provided with a steam-warming apparatus.

In grinding the cacao to powder, as well as for a thorough mixing with sugar, it is necessary that the rotation of the hard granite cylinders, revolving in opposite directions, differs in rapidity. Therefore, the axles of these two cylinders, which have the same diameter, are provided with wheels with different numbers of teeth. So the cylinder attached to the wheel with the smallest number of teeth revolves more slowly than the one attached to the wheel with the largest number of teeth. If, for instance, one wheel has six teeth and the other twelve, the latter will turn twice as quickly as the former.

The spices, volatile oils, or vanilla which chocolate contains as a rule are only added to the chocolate-mass (*i.e.*, cacao plus sugar) towards the end of the grinding process, in order to prevent a loss of perfume, which would certainly take place during a prolonged heating in the grinding and mixing machines. Of course, the cacao is mixed with sugar and spices

MOND GAS MACHINERY IN THE POWER HOUSE

and in the case of some kinds of cheap chocolate with different kinds of meal, in different proportions. In general from fifty to sixty parts of sugar are mixed with from fifty to seventy parts of chocolate, with small quantities of the necessary spices either as powders or in alcoholic solutions of their volatile oils. If chocolate, composed of equal quantities of sugar and cacao is too fatty, in consequence of the large quantity of butter contained in the beans, to be easily moulded into the forms wanted, part of the mass is replaced by an equal quantity of cacao powder of the same mixture of beans from which the fat has partly been extracted. This is what is done in the case of expensive chocolate. In the case of cheap chocolate, however, the same end is attained by adding more sugar. If the chocolate-mass contains more than sixty per cent. of sugar, it is impossible to mould it into different shapes, and pure cacao-butter must then be added.

In the preparation of chocolate-powder, or cocoa, as we are accustomed to call it, the partial extraction of the fat takes the place of the mixing with sugar. This extraction is effected by means of a powerful hydraulic press. A picture of one made by the firm of Lehmann's, as used in Messrs. Cadbury's works, is shown. The mode of extraction is similar to that described for other oils in the section on that group of products.

Three distinct products are found in the shops :-

(1) Cacao nibs, simply the broken-up pieces of the roasted beans.

(2) Chocolate, the ground nibs with the addition of sugar and flavouring materials.

(3) Cocoa used for a beverage, the ground nibs with most of the fat extracted.

The cocoa powder is put up in packets, tins, etc., and is at once ready for sale. Chocolate passes through various processes, and finally whilst still in the semi-liquid or pasty condition is cast in moulds, of any desired shape, so as to form tablets, croquettes, or fancy articles such as cigars, animals, eggs, etc. As is well known, chocolate is usually exceptionally well packed in order to preserve it in the best possible condition.

During the different processes chocolate undergoes, especially during the grinding, air bubbles accumulate in the mass. In order to get these out, the chocolate is passed through a kind of press, which it leaves in the form of a cylinder, and subsequently is reduced to a certain thickness by a roller. The mass is cut into pieces each of the proper weight required for a tablet. Of course, the weight of the tablets can be settled beforehand, and is precisely regulated by the size of the moulds, into which the pieces are pressed. The bottom of such a mould is as a rule divided by projecting lines, so that the tablet has corresponding indentures when it is taken out, which allows it to be easily broken up into so many parts.

Simple chocolate-wares, meant for household use, are as a rule moulded into tablets or square blocks of different sizes and weights. The more expensive kinds of chocolate are also sold in these simple forms, and are made in the same way. The smaller tablets, "napolitains"



LABELLING TINS

HYDRAULIC CAKE-BUTTER PRESS



MAKING BOXES FOR TRANSPORT—VAN HOUTEN'S FACTORY

and "croquettes," are made in this way. Other forms of chocolate are more often fashioned in moulds, consisting of two or more parts.

Chocolate-cigars, for instance, are made in a double mould, consisting of two portions, each of which has the shape of half a cigar, the two halves fitting exactly together. They are however, sometimes made by pouring the liquid mass through hollow tubes. Chocolate-fishes and other such simple objects are made in a similar manner. Chocolate-eggs are as a rule made hollow—at least if they are not too small—by taking two moulds each in the form of half an egg-shell, filling them with a thin layer of chocolate, and uniting the two halves thus obtained to make one egg.

Small tablets, fruits, and other objects filled with cream, are made in the following way. The cream filling is made, allowed to harden, and then dipped into the melted chocolate so as to receive a complete coating.

Innumerable other varieties of chocolate and chocolate-coated sweets are made, and it would be impossible to enumerate them and describe their method of preparation here.

It is important to note in comparing the three staple beverages, cocoa, tea and coffee, that only the first named can be regarded as a food. As has been pointed out, the whole cacao-bean is roasted and ground into such a fine powder that it remains in suspension in the water, so that it is all consumed. On the other hand with tea and coffee all that is taken is an infusion or solution of the substances in the leaves or seed, as the case may be, which dissolve in the water. These form only a minute proportion of the products, and the remainder is thrown away. The stimulating principles are very similar in all three, but in cocoa we obtain these with the valuable nutritive materials in addition.



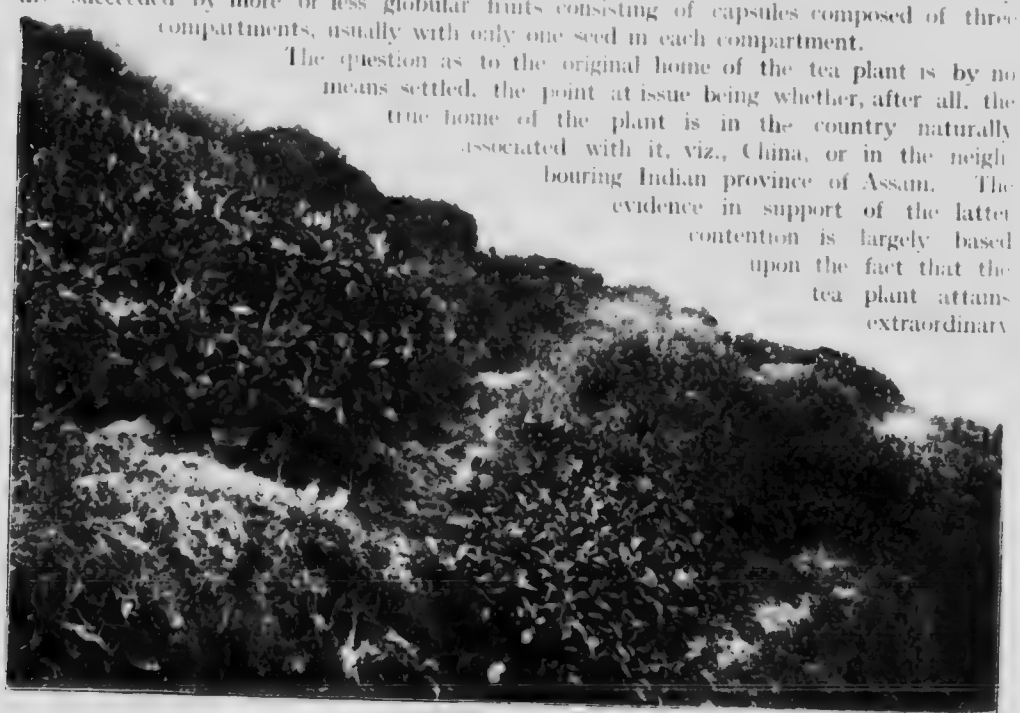
MILLING DEPARTMENT OF A CHOCOLATE FACTORY

TEA

TEA, as everyone knows, is prepared from the young leaves of the tea plant, *Camellia Thea* (Thea sinensis), a shrub belonging to the natural order Theaceae, and extensively cultivated in China, India, and Ceylon, and, to a less extent, in certain other countries. Under the name of *Thea sinensis*, the Swedish botanist, Linnæus, originally described tea as a single species, but later it became known that two distinct plants were cultivated in China, which he named *T. viridis* and *T. Bohea*. These two species were long thought to be the origin of green and black teas respectively. No strictly wild plants have been found in China, but an indigenous tea-tree, *Thea assamica* (or, as it is now called, *Camellia Thea*) occurs in Assam, and is generally regarded by botanists as the parent species of all cultivated forms.

The tea plant is a bushy shrub, which when left to its natural habit of growth and not subjected to the vigorous prunings necessary for its successful cultivation, attains the height of a small tree. The leaves vary considerably in size and shape, according to the variety, but are leathery, alternate, and generally elliptical or lanceolate, with a toothed margin. Oil glands occur in the substance of the leaf and contain an essential oil to which the flavour of tea is largely due. The under surface of the young leaves is thickly covered with fine hairs which entirely disappear with advancing age. The beautiful white or rose-coloured, slightly fragrant, flowers occur either singly or in clusters in the axils of the leaves; they are succeeded by more or less globular fruits consisting of capsules composed of three compartments, usually with only one seed in each compartment.

The question as to the original home of the tea plant is by no means settled, the point at issue being whether, after all, the true home of the plant is in the country naturally associated with it, viz., China, or in the neighbouring Indian province of Assam. The evidence in support of the latter contention is largely based upon the fact that the tea plant attains extraordinary



A HILL-SIDE PLANTATION

A CEYLON TEA GARDEN

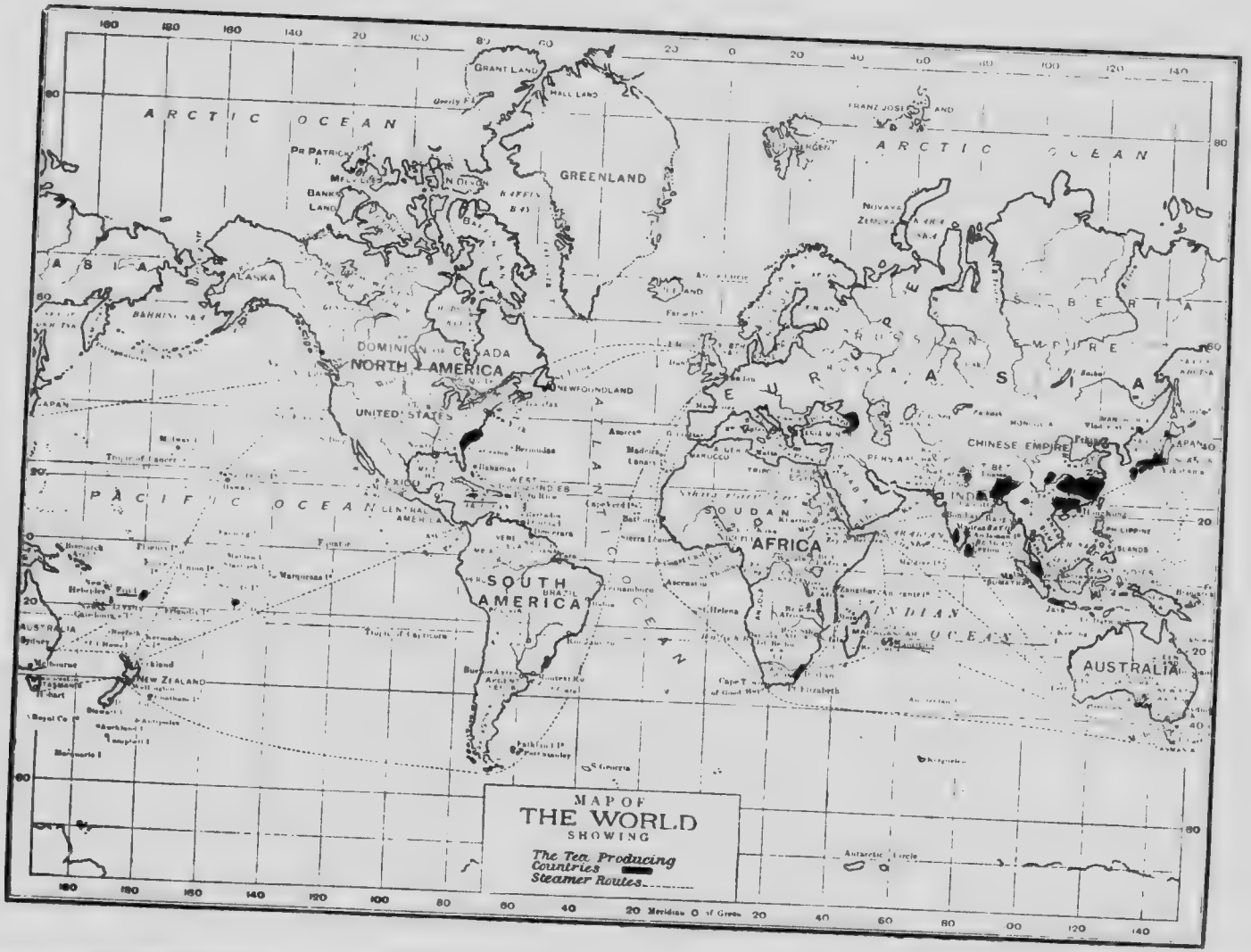
luxuriance in Assam, greater, it is said, than that attained in any part of the Celestial Kingdom; and, arguing that in its natural home a plant reaches its greatest development, supporters of this view maintain that it is in Assam and not in China that we are to look for the home of tea. It by no means follows, however, that the reasoning of this argument is sound, for it has been repeatedly noticed that plants introduced into new countries where conditions seemed favourable for their growth have flourished so well that their luxuriance rivalled that of the plants growing in the land admitted to be their home. Support for the opposite view is sought in a Japanese legend which ascribes to China the honour of being the home of the tea plant: but, unfortunately, there is evidence for supposing that the Chinese never heard of this legend except from foreign sources, although the events related occurred in their own country. There are, however, certain references to the plant in the writings of a Celestial author who lived about 2,700 B.C., and a Chinese commentator of this ancient author, writing in the fourth century B.C., calls attention to the mention of the plant, and adds that a beverage could be obtained from the leaves by adding hot water. It appears that the plant was used entirely as a medicine until 500 A.D., when it became a popular beverage.



PLUCKING TEA

De Candolle, however, in summing up the evidence on both sides, attaches considerable weight to the fact that apparently wild specimens of tea have been found by travellers in Upper Assam and in the province of Cochar, and adds that "the tea plant must be wild in the mountainous region which separates the plains of India from those of China"; he, however, regards the evidence as tending to prove that the *use* of the leaves was introduced into India from the latter country.

Much more certain information naturally exists as to the date of the introduction of the product into Europe. There is a story which states that a package of a commodity hitherto unknown was received by an old couple in England during the reign of Queen Elizabeth and that, instead of infusing the leaves and using the extract, they threw away the coloured


ARCTIC OCEAN
GREENLAND
NORTH AMERICA
DOMINION OF CANADA
UNITED STATES
NEWFOUNDLAND
PACIFIC OCEAN
SOUTH AMERICA
EUROPE
ASIA
AFRICA
INDIAN OCEAN
AUSTRALIA
CHINESE EMPIRE
MAP OF
THE WORLD
SHOWING
The Tea Producing Countries
Steamer Routes



PLUCKING TEA IN ASSAM

liquid and ate the leaves after spreading them upon bread. Whatever may be said as to the probability of this story, it is definitely known that tea was introduced into Europe from China late in the sixteenth century, and that in 1657 a regular tea-house was opened in Exchange Alley, London. From this date tea began to be a regular beverage in England. It is mentioned by Pepys in his Diary; under the date 28th September, 1660, we read: "I did send for a cup of tea (a China drink), of which I had never drunk before," and, "Home, and there find my wife making of tea, a drink which Mr. Pelling the Pothicary tells her is good for her cold and defluxions." It was at about the time of its earliest introduction into England that tea first became known in Russia, an embassy to the Court of Pekin bringing back some green tea to the ancient capital, Moscow. In 1664 the famous English East India Company made a present of two pounds of tea to the queen of Charles II, Catherine of Braganza, and the product was still regarded as a rare delicacy. Fourteen years later the Company imported from China nearly 5,000 lbs. and towards the end of the century tea had ceased to be a rarity.

At the present time the average annual export of tea from the countries producing it, irrespective of the amount consumed in the countries themselves, amounts to about 1,108,828,000 lbs., of a value of over £16,000,000 sterling. Of this huge total, the British Empire is responsible for nearly 350,000,000 lbs., worth no less than £9,217,000, or considerably more than half the value of the world's total production. India heads the list with a total export valued at £5,830,000, followed by that of China, valued at £5,500,000. In spite of this order of precedence, however, it should be noted that the actual *quantity* of tea exported from China is vastly in excess of that from India, being more than three times as much, but the quality of the product is very inferior compared with the Indian article, and hence the difference in value. Third in the list comes Ceylon

with 150,000,000 lbs. worth nearly £3,390,000, followed at a long distance by Japan with 59,000,000 lbs., valued at £541,000, Java with 18,600,000 lbs., valued at £395,000, Formosa with 18,000,000 lbs., valued at £211,000, and Natal and the Caucasus with comparatively trifling amounts.

So much, then, for the principal producing countries. When we turn our attention to the countries and peoples who consume this enormous quantity of beverage-making material, we find that heading the list as the greatest tea importers of the world are the people of the United Kingdom. During the last few years the annual import of tea from all sources into this country has averaged no less than 255,112,000 lbs., costing us £8,683,000! We are followed by Russia, which annually receives about 126,000,000 lbs.; the United States with 81,389,000 lbs., followed by Holland, Australia, Canada, Germany and New Zealand with much smaller amounts.

To us, as English people, a most important question in connection with the world's tea industry is, to what extent is the British-grown article displacing from the world's market the product of our only serious rival, China? Let us consider the state of affairs in some of the chief consuming countries. In the United States and Canada the taste for British-grown teas appears to have taken a firm hold. The quantity sent direct from Calcutta to Canada in 1904 was thirty-five per cent. higher than in 1903. Further, black teas from China have practically disappeared from the Canadian market, and in all probability the green teas from Japan, which at present are very popular in America, will follow them in a few years, for since Ceylon green tea was introduced in 1899 the imports from Japan have decreased from eleven to four million pounds.



JAPANESE WOMEN PLUCKING TEA

The United States takes half as much again Indian tea as it did a year or so ago, and the increase in popularity of the beverage among our cousins gives hope to the Eastern planters of the creation of a new market of the greatest value. Australia, like the rest of the world, is changing her taste in tea. Formerly her supplies were largely obtained from China, but the imports from that country are steadily diminishing. Although considerable quantities of tea are now taken from Java, the real fight for the Australian market lies between Ceylon and India. At the present time the advantage lies with Ceylon, whose exports to the Southern Empire have increased during the last ten years from ten to twenty-four million pounds.

Great efforts, attended with considerable success, are being made to develop the Asiatic trade in British-grown tea, and Persia is now the fourth largest consumer of the Indian product. The preparation of brick tea for Tibet is also receiving much attention at the hands of Indian planters, who have voluntarily submitted to a self-imposed tax to be devoted to pushing their production among the Tibetans.

Austria, Belgium, Sweden, Holland, Turkey, France, and Russia are all advancing in their tea imports. Much of the tea taken by Holland naturally comes from their colony of Java, but the increase in the Russian import nearly all comes from British sources, to the loss of the Chinese merchant.

Although one of the most striking facts in connection with the tea export trade is the practical loss to China of some of the most important of the world's markets, it must not be supposed that the tea industry in China is ruined. As a matter of fact, the area under cultivation has not diminished to any appreciable extent during the past forty years; for the Chinese grower has a vast local market, and immense quantities of inferior tea are converted into the "brick tea" for Tibet and Russia. Moreover, at the present time, there are unmistakable signs that the Chinese intend to make a bold bid for the recovery of some of the ground they have lost; for the more enlightened among them have realised that the trade was lost owing to inferior, and to the Western mind sometimes repulsive, methods of manufacture, and also to the fact that, generally speaking, hand labour must at last give way before machinery. That the Chinese are serious in their desire to regain their trade is evidenced by the fact that in 1905 the Viceroy of Nanking appointed a Chinese Tea Commission, headed by an Englishman, Mr. Lyall, to enquire into the methods and conditions of tea cultivation and manufacture in India and Ceylon. As a whole the Chinese soil is said to be less productive with regard to tea than that of our Eastern Empire, and the climate of the tea districts is colder and less forcing: further, the yield per acre cannot compare with that obtained by the European planters. Nevertheless, the ruling classes in China have become alarmed at the great falling off in revenue due to the diminution of the export trade, for there are heavy Chinese transit and export duties on the product, and it is their intention to see what improved methods of cultivation and manufacture can do to restore this



CHINESE METHOD OF ROLLING THE LEAF



CHESTS OF CHINESE TEA READY FOR SHIPMENT

trade. Whether the Chinese peasant can be induced to depart from the methods and customs which have been handed down to him for countless generations is a matter open to question, but the attempt on the part of the authorities is significant, and the situation may be very accurately summed up in the words of an editorial of a Ceylon planting paper: "... The way in which it (*i.e.*, the Chinese trade) has steadily gone back during the last fifty years is not at all conclusive proof that there can be no important recovery, under changed conditions and methods. In other words, the swing of the pendulum may be witnessed in this department of agriculture and commerce as well as in any other, seeing that the (Chinese) tea gardens have suffered no radical injury."

When we examine the figures showing the amount of tea annually consumed per head of the population we find that although it is a British country which heads the list, the tea-drinkers of Great Britain must give way to their sons and daughters of Australasia, who use no less than 7·1 lbs. per person every year. In the United Kingdom the amount is about a pound less, viz., 6·03 lbs. per head, and then we have Canada (4 lbs.), Holland (1·4 lb.), United States (1·30 lb.), Russia (1·25 lb.), Norway (1·10 lb.), Denmark (0·36 lb.), Germany (0·13 lb.), and France (0·06 lb.). The large consumption in the British Empire is very striking, though not unexpectedly so: but to the average Englishman the most surprising feature of these figures is the relatively small amount consumed per head of the population of Russia. In this country the Russians are commonly regarded as a great tea-drinking people, but this is a popular error, for only the comparatively wealthy classes in Russia can afford to buy tea, which is quite beyond the reach of the poor peasants who form the great bulk of the population.

The rise in popularity of tea in England was comparatively slow up to the beginning of the nineteenth century. In 1711 the consumption per head was only 0·03 lb., and in 1780 it had risen to only 0·57 lb. During the first four decades of the next century the average stood at about 1·25 lb., but after 1840, the period at which tea-planting was rapidly being extended in India, the consumption rose very quickly. In spite of the increasing consumption, however, tea has continued to fall in price owing to the enormous increase in production.

With regard to the chemistry of tea, the most important constituents from the point of view of the quality of the beverage are an essential oil, tannin, and an alkaloid known as theine. The flavour of the tea is largely due to the essential oil, but the remarkable stimulating and refreshing qualities of the beverage are due to the theine which is also found in coffee, Paraguay



CHINESE PACKING TEA

tea, or maté, and the kola nut; a closely allied alkaloid is also present in cacao. Experiment has shown that an infusion of the leaf for ten minutes is sufficient to extract all the valuable theine, and a longer period merely results in an accumulation of tannin which, in excess, is well known to seriously impede digestion.

We will now turn our attention to a consideration of the principal facts in connection with tea cultivation in different parts of the world. Priority must naturally be given to an account of the

CHINESE METHODS OF CULTIVATION AND MANUFACTURE

As is the case in nearly all branches of Chinese agriculture, the tea farms are mostly small, each consisting of from four to five acres. Practically every cottager has his own little tea garden, the produce of which supplies the wants of his family, and the surplus brings him in a few dollars with which he procures the other necessaries of life.

In the green-tea districts of Chekiang picking commences about the middle of April. The first crop of leaves consists of the leaf-buds just as they are about to open, and the tea manufactured from the first pickings is of extremely delicate flavour, being held in such high esteem by the natives as to be used chiefly for making presents to friends. The plucking of the young buds is liable to cause considerable injury to the plants, but, under the influence of the copious showers which generally fall about this time of the year, the plants, if young and vigorous, rapidly put out fresh shoots and leaves. Two or three weeks later the shrubs are ready for the second plucking, which is the most important of the season, and as soon as the plants have again recovered, the third and last gathering commences, producing a very inferior variety of tea.

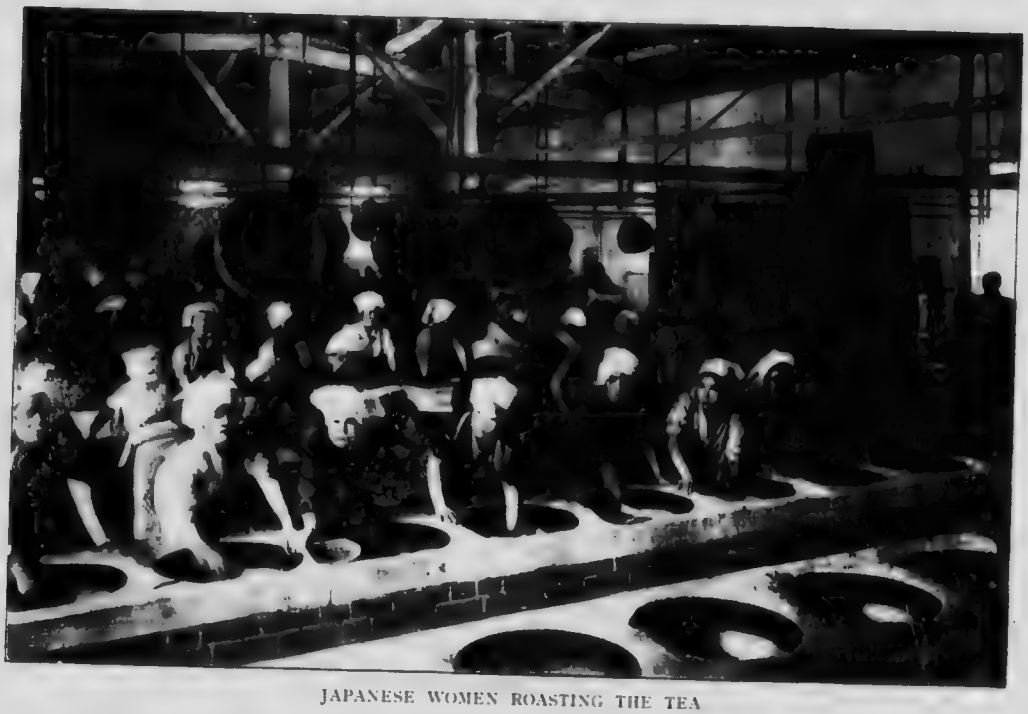
The methods and apparatus employed by the Chinese in the manufacture of their teas are extremely simple, yet, with the abundance of labour obtainable, they are by no means ineffective. A large proportion of the tea is prepared in the humble cottages of the peasants, and barns, sheds, and outhouses are also frequently used for the same purpose, particularly those belonging to the monasteries and temples. The drying pans and furnaces in these places are of very primitive construction. The shallow, circular pans, made of very thin iron, closely resemble in shape and size the ordinary cooking pans which the Chinese have in general use for the preparation of their rice. They are built, several together, in a brick-work furnace which is so constructed that the sloping sides of the basin are continued upwards for three parts of the circumference, resulting in what is practically a broad, shallow brick and cement basin, the actual bottom of which consists of the thin iron pan. The object of this arrangement is to allow of the easy and thorough mixture of the leaves during the roasting process. Running beneath the whole row of pans is a flue, the fireplace being at one end, and a rough chimney at the other.

After the leaves have been brought in from the plantations, they are placed in a shed or drying-house, which may indeed be the cottage itself. The fire is then kindled in the furnace

and a quantity of leaves thrown into the heated pans and constantly turned over and kept in motion by men and women stationed in front of the pans. The heat immediately causes the leaves to crack and become quite moist with the sap which is given out under its influence, and in about five minutes the process is complete, the leaves having become quite soft, pliable, and altogether devoid of their original crispness. The leaves are then taken from the pans and placed upon bamboo tables, around which stand several persons, who take a quantity of the leaves in their hands and carefully roll them on the table in a manner closely resembling the working and kneading of ordinary baker's dough. The object of this process, which lasts about five or six minutes, is to twist the leaves and, at the same time, to express the sap and moisture, which escapes through the interstices of the surface of the table. In the next stage of the process the object is to expel the moisture as gradually and gently as possible, retaining the softness and elasticity of the leaves to the fullest extent. This is effected by taking the rolled leaves, spreading them out thinly and evenly upon a screen made of strips of the ever-useful bamboo, and exposing them to the action of the atmosphere. There can be no fixed time for the completion of this process, which depends entirely upon the state of the weather, but experience has taught the operators to avoid placing the leaves in the direct rays of a powerful sun, which evaporates the moisture too rapidly, leaving the leaves crisp, coarse, and quite unfit for the next stage in the manufacture. The soft and pliant leaves are now again thrown into the drying-pans, and subjected to the action of a slow, steady fire. It is of great importance that the leaves should not be scorched or burned, and it is the custom for one person to attend solely to the fire while others, standing in front of the pans, mix and agitate the leaves with their hands so that all shall be equally dried. As the temperature increases it becomes impossible to mix the leaves by hand, so small bamboo whisks or brushes are employed, the leaves being thrown up against the sloping sides of the pans and allowed to roll back into the iron portion at the bottom. The leaves gradually part with their moisture, twist and curl, and after about an hour, are taken from the pans, to constitute the finished product. Tea so prepared is green in colour, but it lacks the vividness of colour which characterises much of the green teas exported to Europe and America, and which, in former days, at any rate, was produced at Canton by dyeing the leaves with gypsum and Prussian blue. It is a significant statement of Chinese travellers that the Chinese themselves never use the artificially coloured teas!



TEA CARAVAN IN THE STREETS OF PEKIN



JAPANESE WOMEN ROASTING THE TEA

When the tea finally leaves the drying-pans it is picked over and sifted, and finally sorted into different grades previous to packing. If the tea is intended for export, this is a very important process, since the value of a consignment largely depends upon the "evenness" of the leaf, and considerable experience and manual dexterity are necessary to ensure the tea being of the same grade and quality throughout. Once satisfactorily sorted, the tea is put into boxes or baskets and pressed down by men treading it with their feet, which are covered with clean cloth or straw shoes put on for the purpose.

Up to the end of the rolling process, the preparation of black teas proceeds upon lines exactly similar to those described above, but after the rolling, the leaves are subjected to a much more extended drying process in the open air, the period lasting for two or three days. The difference in the colour and character of the teas almost entirely depends upon the differences in the methods of preparation at this stage, and, since the matter is more fully dealt with below in connection with the Ceylon and Indian industry, it will be sufficient to add that the leaves intended to produce black tea, during this extended exposure to the atmosphere, undergo a process of fermentation which does not obtain in the manufacture of green teas. Great care is taken in the final drying or "firing" of the black teas, an experienced and generally old man being invariably employed to regulate the furnace while the other members of the family keep the leaves constantly agitated in the pans. The finished tea is then sorted and packed as in the case of the green varieties.

The teas, whether green or black, have next to be sold, and at the end of the season, the great tea merchants or their agents visit the tea districts, taking with them large supplies of copper coin with which to pay for the commodity. The merchants generally put up at the local inn, and as soon as they have arrived, the growers bring in their baskets of tea, slung on bamboo poles, to submit them to the inspection of the prospective buyer. If the quality is satisfactory the bargain is struck and the tea and money change hands. Should the tea not meet with the approval of the merchant, it is promptly taken away and offered in



JAPANESE ROLLING THE LEAF BY HAND



AN INDIAN TEA NURSERY

other quarters until a sale is effected. The teas bought up in a district are then conveyed to the most convenient town, where they are again graded and packed into chests for the foreign markets.

The purest of all teas, which is least touched by the human hand in its manufacture, is the Virgin Tea of China. It is prepared exclusively from the very youngest leaves of the shrub and is used principally at Chinese marriages, and so delicate are the leaves that even after prolonged boiling but little tannin is evident. The leaves are tied together with silk thread in tiny bundles, and when the tea is to be brewed a bundle of the leaves is held in a large clear crystal cup of very thin glass by means of a small ivory or silver skewer, and the boiling water poured in. The leaves slowly unfold and, changing colour from the dingy greyish-black condition, quickly revert to nearly the same refreshing greenness which they possessed when they were plucked. The infusion, as seen through the glass, is of a pale amber colour, resembling that of the finest qualities of cognac; it is drunk directly from the leaves, the aroma and odour being obtained to perfection.

The Chinese are experts in the adulteration of tea. They use for this purpose the leaves of the rose, ash, and plum, rhododendron, buckthorn, and many other plants. The teas are also scented with the flowers of an olive (*Olea fragrans*), *Chloranthus inconspicuus*, and species of *Gardenia* and *Jasminum*. Even mineral adulterants are also employed to give weight and colour.

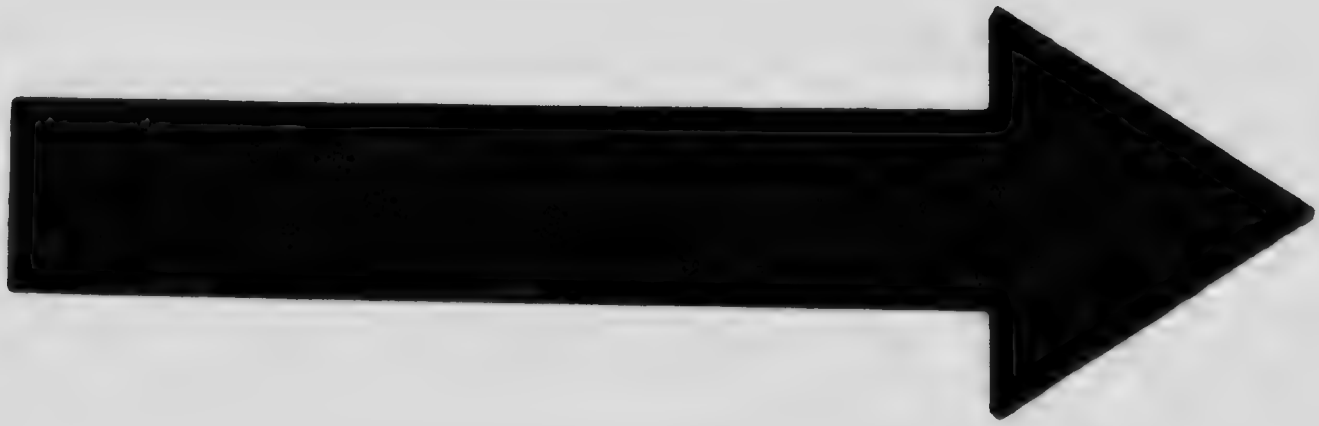
It was largely owing to the jealousy of the Chinese Government in preventing the visits of foreigners to the great tea-growing districts, that the mystery surrounding the origin of "black" and "green" teas was not finally cleared up until nearly the middle of last century. Up to that time we find English writers contradicting one another, some asserting that the black and green teas were produced from the same variety of the tea plant, the differences in the finished product being due entirely to differences in the process of manufacture, and others equally convinced that the two kinds of tea were produced from distinct varieties of the tea plant, the "black" teas being prepared from the leaves of *Thea Bohea* and the "green" teas from *Thea viridis*, both plants being well known in England. During the early part of the nineteenth century, however, the great botanist, Robert Fortune, was travelling in China on behalf of the Horticultural Society, and it was due to the efforts of this observer that the mystery was at last explained. The tea-growing districts visited by Fortune were those of Canton, Fokien, and Chekiang. Up to the time of his investigations upon the matter, Fortune had held to the view of the dual origin of the two varieties of tea, and was gratified to find that, while in Canton black tea was obtained from a plant which he identified as the true *Thea Bohea*, in the green-tea districts of the province of Chekiang he failed to meet with a single plant of this species, and further, all the green-tea plants he was able to examine in the Ning-po country and in the islands of the Chusan Archipelago, proved to be, without exception,

Thea viridis. Fortune then left for the province of Fokien, fully convinced that he would find the tea hills covered with *Thea Bohea*, since black tea was largely produced in the district, and the species took its name from the Bohea hills in this province. In his book, "Wanderings in China," Fortune proceeds: "Great was my surprise to find all the tea plants on the tea hills near Foo-chow exactly the same as those in the green-tea districts of the north. Here were then green-tea plantations on black-tea hills, and not a single plant of the *Thea Bohea* to be seen. Moreover, at the time of my visit, the natives were busily employed in the *manufacture of black teas*. Although the specific differences of the tea-plants were well known to me,



TRANSPLANTING YOUNG TEA PLANTS

I was so much surprised, and I may add amused, at this discovery, that I procured a set of specimens for the herbarium, and also dug up a living plant, which I took northward to Chekiang. On comparing it with those which grow on the green-tea hills, no difference whatever was observed. It appears, therefore, that the black and green teas of the northern districts of China (those districts in which the greatest part of the teas for the foreign markets are made) are both produced from the same variety, and that that variety is the *Thea viridis*, or what is commonly called the green-tea plant. On the other hand, those black and green teas which are manufactured in considerable quantities in the vicinity of Canton are obtained from the *Thea Bohea*, or black tea. And, really, when we give the subject our unprejudiced consideration, there seems nothing surprising in this state of things. Moreover, we must bear in mind that our former opinions were formed upon statements made to us by the Chinese at Canton, who will say anything which suits their purpose, and rarely give themselves any trouble





PRUNING TEA IN CEYLON

to ascertain whether the information they communicate be true or false." It was thus definitely proved that the differences in the teas reaching this country were not due to specific differences in the tea plants, but were produced as a result of differences in methods of manufacture.

TEA IN JAPAN

The success which has attended the efforts of Indian and Ceylon planters to oust China teas from some of the most important of the world's markets is one of the most striking facts in the history of the tea trade. Up to the present, however, the British planter has made comparatively little impression upon the volume of the Japanese export trade in tea, and in the United States and Canada the product of Japan holds a position which appears to be very secure, while certain grades have earned a reputation which cannot readily be shaken. Within recent years considerable attention has been paid by British growers to the Japanese tea industry, and several reports have been issued as a result of investigations carried out on the spot. Japanese teas may be divided into four classes: (1) Hikacha or Yencha, a powdered tea of high quality used only on ceremonial occasions; (2) Green tea, subdivided into Gyokuro ("pearly dew"), and Sencha, the latter being inferior to Gyokuro in quality, but constituting the bulk of the tea drunk by the people; (3) Bancha, consisting of the previous year's leaves mixed with withered stalks and chopped twigs; (4) Oolong and Black tea. With regard to the Black teas it is interesting to note that comparatively little is produced in Japan, since for some reason not sufficiently understood, but probably due to imperfect methods, the native leaf does not undergo the fermentation processes successfully, and poor results generally attend the efforts made to obtain a good black tea. The Oolong varieties have the colour and appearance of black tea but possess the flavour of green tea. Japan proper produces very little Oolong, but large quantities are shipped from Formosa.

The teas most interesting to the British planter, however, are the Gyokuro and Sencha green teas, for these are the grades exported to the American continent, where green teas have a great hold upon the popular taste. They further form the bulk of tea consumed by the Japanese themselves.

The Japanese tea-planter prefers the lower slopes of the hills for setting out his bushes, although, providing that the drainage is satisfactory, successful plantations can be laid

out on the level plains. The famous Uji tea gardens are mostly on the plains. It frequently happens that the tea is interplanted with other crops, mulberries and plums being often grown between the tea bushes, while in one district pears are grown on trellises placed above the tea. The bushes are usually allowed to reach a height of about three feet, but in the Uji gardens they frequently attain to six feet. A peculiarity of the Uji district is that a large part of the tea is cultivated under artificial shade, the effect being to produce a better quality of leaf of a darker green colour. Bamboo poles are set up at intervals and arranged to support horizontal mats also made of bamboo. After the crop has been plucked the matting and poles are taken down. This shade-grown tea is highly valued by the Japanese, and it is grown exclusively for home consumption. Picking usually begins at the end of the third or fourth year and the best leaf is obtained from the eighth to the fifteenth year. The ordinary life of the bush is about twenty-five years. There are, as a rule, two crops in the year, one in May and the second in the middle of June, after the rains; a third crop is sometimes obtained, but the quality of the leaf is very poor. The bushes are pruned after the first crop, and again during the winter.

In the manufacture of the teas it is interesting to note that in the case of the better-class green teas, and a considerable proportion of Sencha, no machinery is used, the whole process being carried out by hand, the popular belief being that it is impossible to procure with machinery the delicate aroma produced by the old fashioned hand methods. For the production of teas destined for the export trade, however, machinery has entirely supplanted hand labour.

The preparation of the leaves begins as soon as possible after picking, and in the case of Sencha, which forms the bulk of the tea consumed in Japan, the first process is said to be that of steaming. The steam is allowed to act on the leaves for about four minutes, when they are shaken by hand, and spread out on mats to dry. The important process of firing now



A KANGANI SUPERINTENDING THE PLUCKING

follows. The workman first smears the surface of the paper lining of the firing tray with rice paste, which, when dry, affords a hard polished surface. A small quantity of the steamed leaf is then poured into the tray, which the workman turns over repeatedly until the edges of the leaves begin to curl as a result of the heat and mechanical friction. The workman then works the leaf into balls, which he breaks and again works up, extracting, meanwhile, the stalks, dried leaf, and other impurities. As the firing progresses, the fresh green colour of the leaves gradually changes to an olive brown, and the fragrant odour of the tea becomes perceptible. The mass gradually shrinks in size as the moisture evaporates, and when finally pronounced to be dry—the whole operation of firing lasts about three hours—it is seen that each leaf is separately twisted and rolled. The tea is then spread out on paper-lined trays similar to those used for firing, and left until the leaves become quite brittle. If destined for home consumption the leaves are sifted with bamboo hand sieves of three or four degrees of fineness, and any impurities remaining are removed by hand; if for export, the sifting is not carried out, but the tea is immediately packed in cases made of thick cartridge paper and despatched to the wholesale merchant.



WEIGHING THE DAY'S PLUCKING

The methods of cultivation and processes of manufacture adopted in the case of Gyokuro and Hikacha teas—the finest qualities—are said to differ in several respects from those described above for the bulk of the tea raised in Japan; but the actual details are not perfectly known.

TEA IN CEYLON

The story of the rise of the tea industry in Ceylon is one of the most interesting in the history of planting. Up to the middle of the last century, coffee had been the most



TEA PLANT

important of the European cultivations, but in the sixties a terrible fungal disease commenced its ravages in the coffee plantations of the island, and after a comparatively few years it was evident that the industry was doomed. The enormous losses, widespread consternation, and distress occasioned by this calamity will be referred to in the article dealing with coffee, and need be no more than mentioned here: but in spite of the blow which had been dealt them, the planters with commendable pluck and energy turned all their attention to the discovery of other crops suitable to the climate and conditions of Ceylon, with which their broken fortunes might be restored. Attention was given to cinchona, cardamoms, cacao, and other crops without any great measure of success: but it was not until they seriously turned their attention to tea that the panacea was discovered. It was found that the warm,



TEA PLANTATIONS NEAR BATOUM

damp climate of many parts of the island was pre-eminently suited to the cultivation of the new crop; moreover the hardiness of the tea-plant when compared with coffee soon raised the hopes of the planters and encouraged them in their new efforts.

It has been frequently stated that tea was found to be already existing in Ceylon by the Dutch, who occupied the island before the advent of the British: but this statement lacks any really satisfactory confirmation. A very small amount of tea was originally planted out in Ceylon as early as 1839: but the first regular plantation was not opened out until 1867, when Messrs. Keir, Dundas & Co. started to raise tea at Yoolcondura. The area was about ten acres, and for some few years the industry made no great strides: in 1877 some 2,720 acres were under tea, which ten years later had increased to 170,000 acres. In 1897 the area had grown to 350,000 acres, and last year (1905) the official returns showed an area of 390,000 acres.

The area recorded for 1905 includes a certain acreage which has been interplanted with rubber, and in Ferguson's Ceylon Handbook it is estimated that the actual area under tea last year was about 380,000 acres. One of the most noticeable facts borne out by a study of Ceylon tea statistics is that whereas during the period up to 1890 the acreage had increased by leaps and bounds, during the last ten years or so the area planted has been practically



THE TEA HARVEST AT BATOUM

stationary, and it is the opinion of those best able to judge that, for the present at any rate, the growth of the tea industry has reached its upper limit.

The average size of an estate in Ceylon is about 300 acres. As in so many industries in all parts of the world, there has been a tendency of late years to group several estates under one working staff to effect economies in working and management expenses, but, nevertheless, by far the greatest proportion of estates are small, and in the hands of the European planters resident on the estates themselves. In a very large number of cases, perhaps in the majority, the estates are owned by companies and the planters are servants of the company, and not the actual owners of the estates, as was more often the case in former years.

The enormous labour supply necessary for the Ceylon plantations is recruited principally from among the Tamils of Southern India, who have proved themselves to be, on the whole, very satisfactory labourers. The people—men, women, and children—are recruited from their villages by their future overseers, who are locally known as "Kanganies," and while the majority return to their homes with accumulated savings, some elect to settle down in Ceylon for life. The approximate number of coolies employed is about 400,000.

By far the greater part of Ceylon tea is exported to the United Kingdom. Next to England, the most important customer is Australia, followed by Russia and America. At the present time special attention is being paid to the production of green teas, the object in view being to foster the American market. The total exports from Ceylon in 1905 were approximately 160,000,000 lbs.

TEA IN INDIA

The first practical suggestion for the establishment of tea plantations in India was made in 1788 by Sir Joseph Banks to the East India Company; but his suggestions were not acted upon until 1833, when experimental plantations were laid out in the

district of Kumaon, in the Himalayas, the seeds and plants used being imported from China. No sooner had the experiments been initiated than attention was drawn to the statement that a tea plant indigenous to Assam had been discovered some years before, and that this variety was probably more suited to cultivation than the Chinese plant. The announcement was received with a certain amount of scepticism on the part of experts, but a travelling commission was sent to Assam to settle the matter. Although an undoubted tea plant, now known as *Thea assamica*, was found to occur abundantly, it was regarded as a degenerate form of the Chinese variety; the committee therefore recommended the further cultivation of plants from China. In 1837 and the years immediately following, discoveries of extensive tracts of country in Assam bearing the indigenous tea were made, and in 1838 the first consignment of Indian tea, consisting of 488 lbs., was sent to London, the price obtained being 9s. 5d. per lb. About this time the principal plantations came under the control of the famous Assam Company, and by 1854 the Indian export had risen to a quarter of a million pounds. Planting was then started in Cachar and Sylhet, and in 1858-9 the plantations of Darjeeling were commenced. Since that time the industry has made enormous strides, and several other districts have imitated the example of Assam and planted out large areas in tea. At the present day the tea districts of India are Eastern Bengal and Assam, with 422,335 acres; Bengal (Darjeeling and Chota Nagpur), with 53,024 acres; Northern India (United Provinces and Punjab), with 17,346 acres; Southern India (Madras and Travancore), with 38,789 acres; a grand total of 531,494 acres, with a total production last year of 221,068,000 lbs.! In 1875 the total production was about 26½ million pounds. Of the total export in 1905 the United Kingdom took no less than 166,754,000 lbs., or, roughly speaking, seventy-six per cent. The next best customers were Canada, taking 15,018,000 lbs., followed by Russia with nearly 10,000,000 lbs., and Australia with over 7,000,000 lbs. Other important buyers were Asiatic Turkey, the United States, Ceylon, Persia, China, and Kashmir.

TEA IN NATAL

Next to Ceylon and India, Natal is by far the most important of the tea-producing colonies of the British Empire, and the industry is one of considerable value to the country. From a



TEA FACTORY AT BATOUM

the most reliable records it would appear that the tea plant was introduced into Natal about 1850, from that "clearing-house of the botanical world"—Kew. The most important fact was that the plants flourished in their new home. Tea-growing as a definite industry, however, was not seriously undertaken until about a quarter of a century later. It will be remembered that the destruction of the coffee plantations by a fungoid disease was essentially the cause of the existence of the now splendid Ceylon tea industry, and it was precisely the same misfortune which in 1877-78 necessitated Natal planters seeking a new field for the investment of their capital. When it became evident that coffee was doomed as a cultivation of first-class importance, Mr. (now Sir) J. L. Hulett became convinced that, with suitable plants, tea would prove the salvation of the planters. The



WEIGHING THE DAY'S PLUCKING IN CEYLON

matter was brought before the Lower Tugela Planters' Association, and the Government being asked to render assistance, free freight on seed imported from India was offered to the colonists. The latter formed a syndicate to defray expenses, and seed from Calcutta was landed in Natal in March, 1877, and immediately planted out in nurseries. Unfortunately, about the time the seedlings were planted out a severe drought visited the country, and out of 4,000 plants successfully raised from the seed only 1,200 survived. The seriousness of this set back was increased by the fact that the surviving plants would require three or four years before they would yield any seed for nursery purposes, and it was not until 1880 that seed was gathered from them, the quantity obtained being barely sufficient to plant five acres. In the following year, however, the planters returned to their task with undiminished determination, and, in spite of many subsequent discouragements, the acreage gradually increased until at the present time it extends to over 4,000 acres. The greater part of this area is in the Lower Tugela Division of the country of Victoria, and tea is also grown to a small extent in the Alexandra Division.

The most productive tea gardens are at an elevation of about 1,000 feet, the land at this altitude being generally of an undulating character, well watered, and the climate sufficiently humid to encourage leaf-production. The plucking season commences in September and lasts until June of the following year, during which period each bush is picked about sixteen times.



THE WITHERING PROCESS



A ROLLING MACHINE AT WORK

Undoubtedly the most hopeful outlook for the Natal tea industry lies in capturing the South African market; for, while the annual import of tea into South Africa is considerably over 6,000,000 lbs., the annual production of the commodity in Natal does not exceed more than 2,000,000 lbs. In order to satisfy the local demand it would be necessary to increase the present acreage three-fold, *i.e.*, to about 13,000 acres.

TEA IN THE CAUCASUS

For several years past serious efforts have been made by the Russian Government and by private individuals to establish a tea industry in the neighbourhood of Batoum, in the Caucasus. The Imperial plantations are situated at Chackra, and have an area of about 400 acres, and in 1905 the tea prepared from a plucking of 102 acres reached a total of 21,600 lbs. The Popoff plantations, which are owned by a private firm, are somewhat smaller in area, and are situated at Chackra, Salibauri, and Kaprshun. Up to the present, however, comparatively little progress has been made in the industry, the labour question being one of great difficulty.

OTHER TEA-GROWING COUNTRIES

A small tea industry also exists in Jamaica. In 1868 an acre of land was planted with tea by the Government, and, as the experiment met with some considerable success, the area was later increased. In 1887 there was one private tea-garden in the island at Portland Gap, about twelve miles from Kingston, with twelve acres under cultivation. Nine years later

further experiments were made at Kamble in St. Ann, and the results being successful, the cultivation has gradually increased until, at the present day, there are about ninety acres under the crop.

In Fiji an experiment in tea planting was made in 1880. The island chosen was Taviuni and an area of thirty acres was planted out with the Assam hybrid; the area was gradually extended to several hundred acres, when it became known as the Alpha Tea Estate. The success of this garden—situated within four miles from the coast and at an altitude of 1,000 ft.—led to the establishment of another plantation in the neighbouring island of Vanua Levu, known as the Masusa Estate. Fiji tea is chiefly consumed locally.

Tea is also cultivated in the State of Johore, in the Straits Settlements, and small plantations exist in Burma, the Andamans, and Tonquin. Experiments have also been made in British Central Africa. In Java a valuable export trade is being gradually built up. The first seed was introduced into Java from Japan in 1827 by von Siebold, and young plants were raised in the famous botanical garden at Buitenzorg, but a few years later better varieties were obtained from China by Jacobsen, who may be regarded as the founder of the tea industry in Java.

MODERN METHODS OF CULTIVATION AND MANUFACTURE

We will now turn our attention to the cultivation and manufacture of tea as practised by the European planters of Ceylon and India.

In opening out a new tea garden the first step is the establishment of a nursery for raising the young plants which are to fill the garden. A piece of jungle near the new plantation is cleared; then the soil carefully hoed, and prepared for the seed. The land is now divided into beds between which are shallow trenches, and when the soil is sufficiently prepared, the seed, which has been allowed to sprout in seed beds, is planted out and the ground covered with thatching to prevent scorching by the sun. The nursery is carefully fenced in to prevent damage by cattle and wild animals. The seed is obtained from plants grown in a special "seed garden" where the bushes are not pruned in ordinary cultivation, but allowed to attain their full growth.

Meanwhile the clearing of the future garden has been proceeding, and, when complete, the soil is carefully hoed and then marked out with stakes, about four feet apart, indicating the lines or rows which are to receive the young tea-plants from the nursery. The roads and drains of the plantation are dug by the coolies, and then transplanting commences. The young plants are taken from the nurseries when about twelve inches high, and planted in the holes prepared for them, care being taken to keep the wall of earth round the roots of the seedling intact.



END VIEW OF A ROLLING MACHINE

The plants become well established and ready for picking when three years old, at which time they are sending out abundance of young leaf-shoots, known as the

"flush." From this time onwards the picking or plucking is carried out at regular intervals, and, to induce the formation of abundant flushes, the bushes are pruned from time to time, a process which also keeps the growth of the plant within bounds to allow of the plucking being conveniently performed. In the colder climates of China and Japan, the flushing ceases in the winter; but in Ceylon it goes on all the year round.

In Ceylon the flush is ready for picking every ten or twelve days. The process consists in plucking the young shoots, to include the third or fourth leaf from the bud, and upon the size of the leaf depends the quality of the tea manufacture. Thus, plucking is designated as "fine" when the bud at the top of the shoot and the two young leaves just below it are taken, "medium" when the bud and three, "coarse" when the bud and four leaves are taken. From the "fine" plucking the tea known as "pekoes" are made, "flowery pekoe" being derived from the youngest leaf, "orange pekoe" from the next youngest, and "pekoe" from the third leaf; "souchongs" and "congous" are prepared from the larger leaves. Pekoe-souchong, as the name indicates, is intermediate in quality between pekoe and souchong.

The flush is gathered by the women into baskets and when the latter are full they are taken to the factory to be weighed. The leaf is carried to the upper floor of the factory, where it is thinly spread out on light open-work shelves of canvas, or on wire-meshed trays placed one above the other, in order that the drying or "withering" of the leaf may take place. In good weather the correct degree of flaccidity is reached in seventeen or eighteen hours; but if the weather is damp, artificial heat is employed. The withered leaf is then collected from the trays and thrown down through shoots into the rolling machines,



A SIROCCO FIRING MACHINE



INTERIOR OF A CEYLON TEA FACTORY



FERMENTING THE LEAF

which are generally situated on the ground floor. The object of the rolling process is, firstly, to bruise the leaves so as to allow the leaf juices to become mixed, and, secondly, to impart a twist or curl to the leaf. The rolling machines consist essentially of a table with a central depression to hold the leaf and a hopper above it, the two moving one over the other with an eccentric motion. Any required degree of pressure can be put upon the mass of leaf that is being rolled, and at the end of about an hour the door in the bottom of the machine opens and the roll falls out, the twisted leaves, which have become somewhat yellowish, clinging together in masses which are broken up in a machine known as a "roll breaker"; a "sifter," which separates the coarser leaf from the finer, is usually attached to the breaker. The next process, the fermentation process, is one of the most important in tea manufacture; for on its efficient accomplishment depends to a large extent the quality and character of the tea. Further, the *omission* after this stage in the manufacture results in the formation of "green" teas, which formerly enjoyed great popularity. In the preparation of black teas, then, the rolled leaf is piled in drawers one above the other or on mats, and then left to ferment or oxidise, air being allowed free access. The process occupies a varying length of time according to the particular garden and the condition of the weather. During the fermentation the leaf emits a peculiar odour and changes colour, and after about two hours, when the right degree of copper-brown colour has been attained, the leaf is "fired" in the drying machines, the heat arresting all further fermentation. In many factories the leaf is re-rolled previous to firing. Besides the checking of the fermentation, the object of the

firing process is to remove all the moisture without driving off the essential oil and other constituents, upon which the value of the manufactured article largely depends. The firing is effected by one or more of many types of machines, all of which act by passing a current of hot, dry air through the damp fermented leaf until it is dry and brittle. A commonly used type of machine is the "Sirocco," to the illustration of which the reader is referred. The tea is then taken to the sorting room, where it is sifted into grades by a machine consisting of a series of moving sieves of different sizes of mesh. The resulting siftings are classed as Flowery Orange Pekoe, Orange Pekoe, and Pekoe No. 1, and are known as "unbroken teas." The first mentioned is the least coarse and finest tea, but the coarser tea which does not sift through the meshes is transferred to "breaking machines," and broken up and again sifted, the products being known as Broken Orange Pekoe, Pekoe No. 2, etc. The tea dust which accumulates during these processes is kept separate from the better qualities, and is shipped as "dust" and "fannings."

The processes in the manufacture of green tea in India and Ceylon are similar in most respects to those employed for black tea. The various grades resulting from the sifting receive names different from those applied to black teas, the principal varieties in descending order of quality being Young Hyson, Hyson No. 1, Hyson No. 2, Gunpowder, and Dust. The tea is then packed into lead-lined chests, stamped with the name of the garden or factory, and transported to the quay at Colombo, Calcutta, or Chittagong, whence it is shipped to England.

BRICK TEA

A most interesting variety of tea is that so extensively used in Tibet and some parts of Russia, and known as "Brick Tea." The product may be briefly described as very cheap and coarse teas which, with the small twigs, have been compressed into blocks. The chief centre of the industry is at Ssu-chuan, in Western China, and it has been estimated that the Tibetans annually import the tea to the extent of from twenty to thirty million pounds. Very little care is exercised in the plucking process. The main object of the cultivator is to obtain a good weight of the product with as little trouble as possible, and hence the first six or seven leaves are roughly stripped from the twigs or, as is more generally the case, the twigs, to a length of perhaps twelve inches, are literally reaped from the plant. There is no withering or regular fermentation process; the twigs and leaves are at once heated in thin iron pans for a few minutes, and then tied up into bundles and sacks and taken away to the factories or "hongs," where the material is piled in heaps and allowed to ferment. After being dried in the sun, the tea is sorted into grades, when it is steamed and finally pressed into a shallow brick-shaped mould by means of a heavy rammer; it is often necessary to mix the chopped twigs with a paste made from glutinous rice in order to make them adhesive. In



SIFTING THE TEA WITH SIEVES

three or four days the bricks have become quite hard, and, after being stamped with the maker's name or device, are wrapped in paper and made into strong packages for transport to Tibet.

Large quantities—some 20,000 tons per annum—of a brick tea are made at Hankow, and the same town also manufactures "Tablet Tea," both for the Russian market. The bricks are very different from the Tibetan article, for they are manufactured from tea dust of good quality, the dust being either purchased as such by the factories (which are under Russian control), or else tea is bought and ground to powder by machinery. The tea dust is carefully sifted into grades and steamed for a few minutes, after which it is cast into bricks, in separate moulds, by hydraulic pressure. The bricks are allowed to dry in the moulds for two



COOLIES CARRYING BRICK TEA TO TIBET

or three weeks, when they are packed in bamboo baskets for transport. The Tablet Tea is prepared from the finer grades of tea destined for European Russia.

OTHER "TEAS"

The famous Paraguay Tea, or Yerba de Maté, is one of the most important economic products of South America. The tea is derived principally from the leaves of *Ilex paraguariensis*, although an investigation carried out at Kew a few years since showed that several varieties of this species were concerned in the product, and that it was probable that other species of the same genus were also used as a source of the tea. Further, there was evidence to show that, in addition, the leaves of *Symplocos lanceolata* and *Elaeodendron quadrangulatum*, plants belonging to quite different families, were also used for the same purpose.

By far the greater bulk of maté, however, is prepared from *Ilex paraguariensis*. The

plant is a shrub belonging to the natural order, *Aquifoliaceæ* (Holly family), and bears oval leaves about four or five inches long, with serrated edges. It is found commonly in Brazil and Paraguay, where there are also regular plantations; but the leaves are extensively used throughout South America, and several million pounds of the prepared mate are annually exported from the latter country to various parts of the continent, small quantities are also sent to Europe.

In the preparation of maté the leaves are not plucked from the plant as in the case of ordinary tea; but large leafy branches are cut from the shrub and placed on hurdles over a wood fire until sufficiently roasted. The dried branches are then placed on a hard floor, and the withered leaves beaten with sticks, after which they are reduced to a coarse powder



TRANSPORT OF TEA IN CEYLON

in rude mills. The product is then ready for packing in skins and leather bags. There are said to be three principal grades of maté in the South American market, viz. Caa-Cuys, which is the half-expanded leaf-buds; Caa-Miri, the unroasted leaf from which the principal veins have been removed; and Caa-Guaza, or Yerba de Palos of the Spaniards, which is prepared from the roasted leaves together with the leaf stalks and smaller twigs. The infusion is prepared for drinking by putting a small quantity of the tea in a cup with a little sugar; a drinking-tube or *bombilla*, with a wire network or perforations at the bottom, is then placed in the cup and boiling water poured in the maté. When sufficiently cool, the infusion is sucked up through the tube. Maté has an agreeable, slightly aromatic odour, and a somewhat bitter taste. It is very refreshing, and is a valuable restorative, especially after great physical exertion, while it also possesses mild diuretic and aperient properties.

Another species of *Ilex* (*I. cassine*) was the source of the famous "black drink" of the North American Indians, which is known under the name of "Youpon." The home of the plant is along the eastern and southern shores of the United States, and it is not found

to any great distance inland. It is an elegant shrub ten to fifteen feet high; but sometimes rises into a small tree of twenty to twenty-five feet. The oval, toothed leaves, which are about an inch long and very smooth, were once extensively used by the natives of North America as tea, the preparation of the beverage being very similar to that of ordinary tea.

The method of preparing cassine was comparatively simple. The leaves and tender young branches were carefully picked, the season chosen being the time of harvest. The leaves were dried in the sun or shade and afterwards roasted in ovens, remains of which are still found in the Cherokee region. The roasted leaves were kept in baskets in a dry place until needed for use. An infusion of cassine leaves with boiling water gives, after cooling, a liquor of little taste and slight odour. But, if boiled for an hour, the infusion becomes a very dark liquid, resembling strong black tea of an odour not unlike that of Oolong tea. The taste is similar to that of inferior black tea, quite bitter, but with little flavour.

Besides the different varieties of "tea" described above, there are several plants the leaves of which are used by people in various parts of the world for the preparation of a refreshing drink. Thus, in the Australian colonies the leaves of species of *Leptospermum* and *Melaleuca*, plants belonging to the Eucalyptus family, have been employed as tea, though the quality is not all that could be desired. The famous "Bushman tea" of South Africa is prepared from *Cyclopia genistoides*, and the lemon grass yields an infusion which is drunk by natives of some of the inland districts of India. "Bourbon tea," sometimes known as "Faham tea," is especially interesting since it is one of the very few examples of a product of economic value derived from the Orchid family. The orchid in question is *Angraecum fragrans*, which is found growing as an epiphyte on the trees of the forests of Bourbon, or Réunion, and Mauritius. It is a perennial, producing a few green leaves which have a persistent vanilla-like odour. The beverage is prepared by pouring cold water on to the dried leaves, and boiling the liquor for about ten minutes in a tea kettle or other closed vessel. It is then emptied into the cups or tea-pot, and sweetened according to taste. The tea possesses an aroma of great delicacy, and leaves a lasting fragrance in the mouth.

COFFEE

THE popularity of coffee needs no emphasising, and yet it is only during the last 250 years that this beverage has come to be generally used in the civilised countries of Western Europe. Coffee is now one of the important plants of tropical agriculture, and the annual value of the product is enormous. It has been estimated that there are some 50,000 coffee estates in the world, and that they annually produce coffee to the value of over £50,000,000.



A COFFEE PLANTATION AT BASOKO

To a greater degree than most other agricultural industries, coffee cultivation has been subject to strange vicissitudes. Originally all the coffee consumed in Europe came from Arabia, then the West Indies, and, later, Java



COFFEE PLANTATION WITH INTERPLANTED YOUNG TREES OF ASSAM RUBBER



A LIBERIAN COFFEE PLANT IN FLOWER

became pre-eminent, to be in turn absolutely beaten by Brazil, which at the present time produces some three-quarters of the world's total supply, and controls the market.

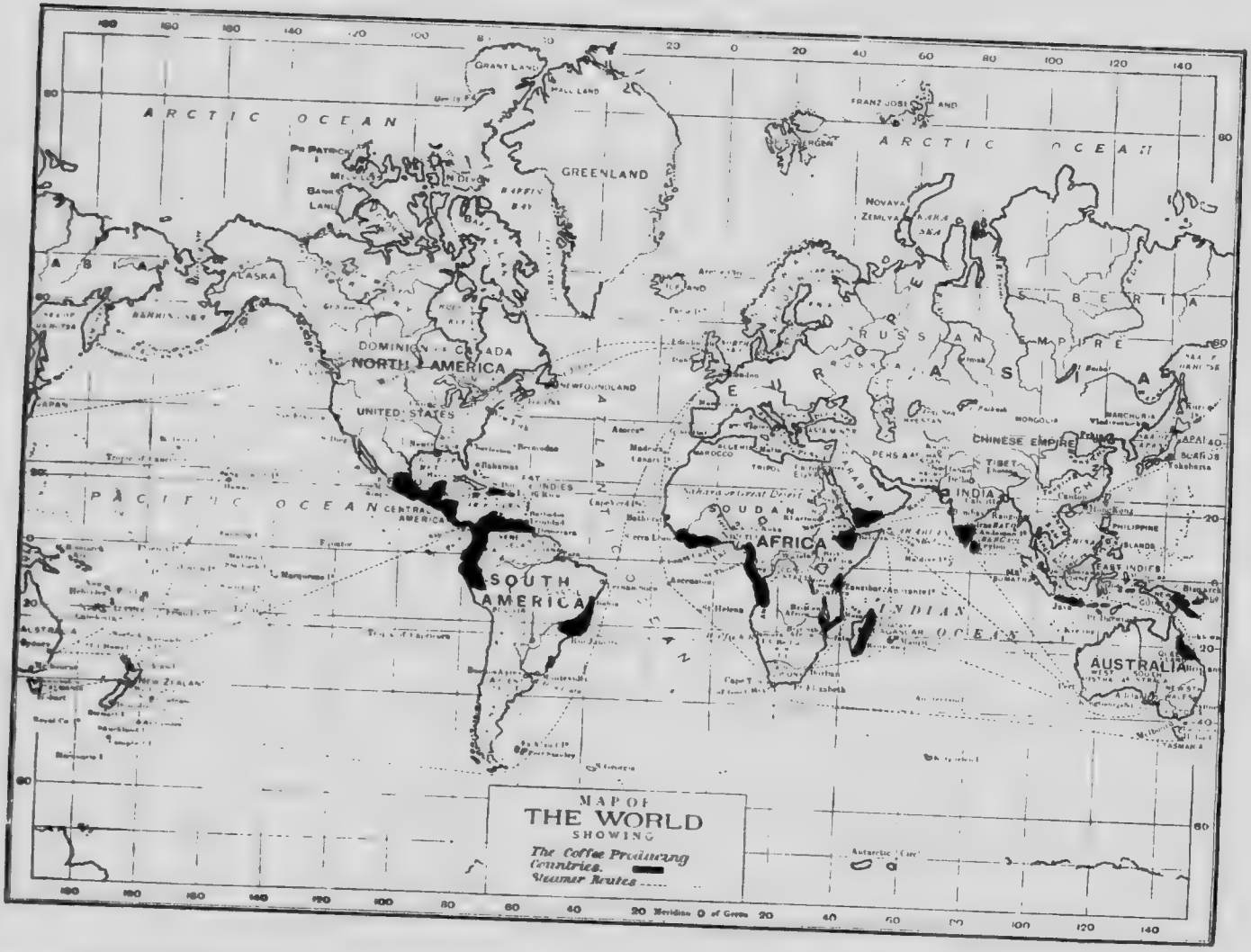
The history of coffee cultivation in Ceylon, to which we shall refer again later, affords a good illustration of these variations in fortune. In 1880 coffee was the principal crop of the colony, and worth some £3,000,000 annually. The attacks of a microscopic fungus ruined the plants, and the industry within a comparatively few years became of quite minor importance, and the annual crop is now worth only about £25,000—a drop in value of £2,975,000 in less than thirty years.

THE COFFEE PLANT

The coffee plant belongs to the genus *Coffea* of the natural order *Rubiaceae*, an assemblage of plants including also the cinchonas, which yield quinine; gambier, furnishing the tanning material and dye of the same name; madder, and other useful plants. The order is most abundantly represented in the tropics, and our British representatives—the bed-straws, goose-grass, and madder—do not possess the characteristic features of their relatives of the warmer regions of the world. Altogether there are about eighty recognised species of *Coffea*, of which only two are cultivated to any great extent, namely Arabian Coffee (*Coffea arabica*) and Liberian Coffee (*C. liberica*).

Arabian and Liberian Coffee

The beautiful Arabian coffee plant is a shrub attaining a height of fifteen or eighteen feet. Its leaves are of a fresh green colour, three to four inches in length, pointed and borne in pairs


ARCTIC OCEAN
GREENLAND
NORTH AMERICA
DOMINION OF CANADA
UNITED STATES
PACIFIC OCEAN
SOUTH AMERICA
AFRICA
INDIA
CHINESE EMPIRE
AUSTRALIA
MAP OF
THE WORLD
SHOWING
The Coffee Producing Countries.
Steamer Routes



LIBERIAN COFFEE. FLOWERS AND RIPE FRUITS OR "CHERRIES"

on the slender branches. The flowers occur clustered in groups of from four to sixteen in the axils of the leaves. They are white in colour and of fragrant odour. The fruits, or so called "cherries," are at first a dark green, but as they ripen the colour gradually changes to yellow and then to red, and at last, when thoroughly ripe, to dark crimson. The outer portion of the fruit is fleshy like a cherry (whence the common name). Each fruit contains two seeds, covered in turn by a dry, smooth, straw-coloured husk, known as the "parchment." The seed itself is of a horny consistency, and will be perfectly familiar to everyone, as it is the unroasted coffee bean of commerce, of characteristic greenish-grey colour. Between each seed and the parchment is a thin membranous covering known as the "silver skin." The two seeds or "beans" which each fruit contains lie with their flat sides together. It often happens, however, that only one of the beans attains full development, in which case it is no longer flat on one side, but more or less circular in section. Such beans form the so-called "pea-berry" coffee. They are carefully separated when the crop is gathered, because they fetch a higher price. In Brazil there is a very rare variety known as the Hybrico-coffee, the fruit of which contains four or six seeds.

The native country of Liberian coffee is not only the negro-republic of that name, but also the other parts of the West Coast of Africa, from Sierra Leone to Angola. Its cultivation is of much more recent date than Arabian coffee, because the product is less valuable; and its first appearance on the European market met with only very moderate success. The first Liberian plants were introduced into Ceylon and into Java after the fearful coffee-leaf disease broke out, in the years 1873 and 1878 respectively. At first it was thought that the Liberian



coffee-plant was not susceptible to the malady; this opinion was, however, cruelly belied, although it was indeed less susceptible, and offered greater resistance than its Arabian cousin. Hence people have gradually learned to appreciate the Liberian plant, if not on account of any superior quality of its fruits, at any rate on account of its power of resistance and its vigorous growth—for which reason it has gradually gained a place for itself in Eastern countries by the side of the Arabian coffee. In America, however, the Arabian variety still holds its own.

The Liberian plant is distinguished from the Arabian by its greater height, which varies between eighteen and thirty-six feet, and also by the dimensions of its leaves, which sometimes attain the length of one foot. The flowers grow in clusters of six or eight together in the axils of the leaves, and exceed those of the Arabian plant in size, while the fruits are also much bigger, having a diameter of about an inch, and do not drop so readily when they are ripe.



FRUITING BRANCH OF ARABIAN COFFEE
(*The background is formed by banana leaves*)

as do those of the Arabian plant. The pulp is less rich in sugar and tougher than that of Arabian coffee, which makes the use of special machines necessary in its preparation.

The aroma of Liberian coffee is not very highly appreciated, which, considering its many other good qualities, especially its great fertility, is much to be regretted; for this reason people in Java have endeavoured to improve the species.

Attempts have been made to attain this end by artificial hybridisation, and for a long time, in Java as well as in British India the hope was cherished of obtaining a race which would unite the merits of Arabian and Liberian coffee. These efforts, however, have not proved very successful, although in a book published in 1899 M. A. J. Thierry records that in Java, owing to the labour of van Riemsdyck, a hybrid has been produced which, when grafted on to Liberian roots, is said to be resistant to coffee-leaf disease.

The grafting of Liberian on to Arabian coffee has not been successful; although the results of experiments in the opposite direction were quite satisfactory. Among other things, it was

observed that such plants suffered less from the attacks of parasites, than those which had not been grafted, especially from those parasites—such as nematode worms—which frequently attack the roots of the Arabian coffee plant but do not usually attack Liberian coffee. By grafting we thus obtain the advantage of the hardy root system of Libertan whilst the produce from the grafted stems is the more highly esteemed Arabian coffee.

The famous Buitenzorg Botanic Gardens, near Batavia, where experiments are made with all kinds of tropical plants, furnished the first seeds of Liberian coffee to the planters of Java in 1878. Since that time the cultivation of this kind of coffee has so rapidly progressed, that at present one-tenth of the State plantations are planted with shrubs of this sort, and one-fourth of the private plantations also.



NURSERY OF COFFEE SEEDLINGS UNDER THE SHADE OF TREES

Other Varieties of Coffee

Over and above the two chief kinds of coffee—Arabian and Liberian—which are described above, the following varieties deserve mention, on account of some peculiar characteristics. The Hybrico-coffee of Brazil already mentioned, with its fruits containing four or six instead of two seeds. The Maragogipe, found in 1870 near the town of the same name of the Brazilian province of Bahia. The leaves of this kind are as large as those of the Liberian coffee, and the seeds are so much in request that people have tried to grow it elsewhere, but accounts vary very much as to its yield. The Botucatu (var. *amarilla*), discovered in the year 1871 in the district of the same name in the province of San Paolo, which the English have introduced into India under the name of "golden drop coffee," but of which the cultivation is not very important.

Experiments have been, and are still continually being made, with numerous varieties in the hope of finding a sort fit for cultivation. These experiments are conducted in various parts of the world with the wild Congo coffee (*Coffea robusta*), and in the Botanic Gardens of Ceylon, Trinidad, and elsewhere, with the Sierra Leone coffee (*Coffea stenophylla*), the beans of which are said to be superior in flavour to those of all other coffees. Another species of coffee (*Coffea*

excelsa) has recently been introduced into the Trinidad Botanic Gardens, and is reported to be of considerable value.

Cultivation

As the methods of the cultivation of coffee and its preparation for market differ to some extent in various parts of the world, it will be best to give first a general account of the processes adopted, and to supplement this afterwards with notes on the industry in the different producing countries.



JAVA. GRAFTED COFFEE PLANTS

Coffee thrives to the best advantage in a hot, moist climate, and on rich, well-drained soil. A high rainfall is usually essential, and anything between 75 and 120 inches per annum is desirable, well distributed. It is true that coffee can be grown in dry regions and yield produce of excellent quality, but then the crop is usually very small. In the tropics coffee is pre-eminently a crop for fairly high elevations, and the best results are attained on estates situated above 2,000 feet, although it will grow almost down to sea level. Liberian coffee gives good results at lower elevations than Arabian.

In South America the coffee grown in very dry regions, situated rather high above the level of the sea, is considered the most fragrant: the fruits are much smaller, however, and the crop less plentiful. In damp regions, above a certain degree of latitude, the plant bears a very rich foliage, at the expense of the fruit. The two things most injurious to its growth are cold, and very hot, dry winds. If the plant is not protected it loses a large part of its foliage on the windy side; sometimes it is even entirely despoiled of its leaves. To prevent this, trees are planted round the coffee plantations to shelter them from the wind.

Propagation. Coffee plants are propagated from seeds, for which the largest and finest fruits from selected trees should be chosen. The seeds may be planted directly in the fields in the positions the future trees are to occupy. The method is commonly known as "planting at stake," because a stake is driven in to mark the position of the seeds, three or more being planted together so as to allow of the weaker plants being pulled up later. This method has several advantages as it does away with the expense and risk of transplanting. On the other hand, if the climate is not sufficiently moist, there is always the possibility of drought injuring, or even killing, the young seedlings. If there is any likelihood of this happening the young plants must be raised in nurseries. When this course is advisable the seeds

A PASHEN COFFEE STAND.

are sown in carefully prepared and thoroughly well-tilled nursery beds, situated so that the plants can readily be watered. It is necessary to afford shade to the young plants, and this can be done by arranging coarse matting, palm leaves, etc., on a framework three or four feet above the ground. When the plants are about one to two feet high they are transplanted to their permanent situations, this being done at a season when showers are frequent. Before transplanting the shade is gradually removed and the plants hardened off exactly as in this country one would prepare seedlings for the difference in climate between a frame, or greenhouse, and a situation in the open. After being transplanted temporary shading is afforded by palm leaves, leafy branches, or in other ways, each country and sometimes each estate



QUEENSLAND. COFFEE EIGHTEEN MONTHS AFTER BEING PLANTED OUT

having its own method in these matters of detail. The distance between the plants varies, but from ten to fifteen feet apart may be taken as about the average planting distance. Catch crops can be cultivated between the rows whilst the coffee plants are young and small. In Brazil, for instance, maize and beans are planted between the young shrubs. These give a useful crop and at the same time serve to shelter the coffee from the sun. Bananas and plantains are commonly employed in a similar way. As soon as the coffee plants become well developed and begin to bear fruit, the other plants should be removed unless there are special considerations which render their retention advisable for a longer period.

Weeding is of great importance in the coffee plantations and requires great care, for in regions of such luxurious growth grasses and weeds display an extraordinary vitality and vigour. In Brazil, with its dry climate, where the coffee-shrubs are planted at sufficient distances from one another, mechanical weeding-knives drawn by negroes are used to clear the plantations, a method which is very little known in other countries.

Shade Trees. So far we have only spoken of the temporary shade provided for the coffee whilst it is young Permanent shade trees are also often planted, amongst the favourites being species of *Erythrina* and other leguminous trees. The necessity for these is a disputed question. Certainly, excellent coffee can be grown without shade, for instance, the Blue Mountain coffee of Jamaica, and in Brazil also shade is not usually employed. The planters of other countries, such as Porto Rico, say that the plants absolutely require shade. Local conditions probably have much to do with this difference of opinion, and it is one of those problems which, as in the case of cacao, each planter must solve for himself as the result of



JAVA. LIBERIAN COFFEE PLANTS THREE TO FOUR YEARS OLD

his own observations. The whole question is fully discussed by Mr. O. F. Cook in an interesting Bulletin of the United States Department of Agriculture, entitled "Shade in Coffee Culture," in which the complex nature of the problem is well brought out. In all probability where shade trees are found to be advantageous their beneficial action is often only indirect, in affording protection from winds, drought, soil erosion, and in that increase of soil fertility which leguminous plants, as a group, bring about.

Fruting. As a rule the coffee shrub first flowers in its third year, and then only bears a small crop of fruit. The fifth year is usually the time of the first considerable yield. Climate and soil have great influence on the blossoming. Where there are no great differences in the temperature in the different seasons the coffee plant bears flowers all the year through, so that at any time of the year an individual plant will bear flowers and fruit in various



LIBERIAN COFFEE CULTIVATION IN SURINAM

stages of development. The gathering of the crop and the treatment of the beans are in such places not restricted to definite seasons—a circumstance which is of no advantage, as the quantity gathered at one time is usually small, and the handling and preparation of the crop is more profitable when large crops are dealt with. It is thus preferable to form plantations in regions where the seasons are sharply distinguished from each other. In Java three gatherings are made annually, called the "early," the "chief," and the "after crop," but only the second, which begins at the commencement of the rainy season, is of great importance.

In the coffee-growing districts of Brazil differences in climate have great influence on the time of flowering, the time of harvest, and the quality of the product. Thus, ripening is hastened in the State of Rio de Janeiro, where it is much warmer than in San Paolo, the consequence of which is that the crop gathered in Rio is ready for sale at least a month earlier than Santos coffee from San Paolo (April and May), whilst in other districts, such as Braganza and Atibaia, the crop is not ready until October.

The flower enjoys only a very ephemeral existence as the setting of the fruit generally takes place within twenty-four hours, and the petals wither and fall off almost immediately. A coffee estate in full flower is a very beautiful sight, but its glory is very soon past and an estate which was a mass of fragrant white blossom one day becomes green again within a comparatively short time. From the time of blossoming to the ripening of the fruits there is a period of some seven or more months.

Picking. It is easy to recognise when coffee fruits are ripe as they are then dark red, and bear a strong resemblance to ripe cherries. The cherries are readily stripped from the branches by hand, and are collected in bags, baskets, or other convenient receptacles. To obtain the best quality product only the ripe "cherries" are gathered, those which are green and unripe being left on for a later picking. Dry and shrivelled up berries must also be



STRAITS SETTLEMENTS. COFFEE PLANTATION WITH SHADE TREES, AND YOUNG RUBBER PLANTS
(The photograph was taken when the shade trees were bare of leaves)

carefully kept apart. The picking requires to be done carefully so as to prevent the plant as well as the fruit from being damaged.

The Arabs allow the fruits to mature fully until they fall off of their own accord, or are made to fall by slightly shaking the plants, a cloth often being spread beneath. This ensures only quite ripe fruit being collected, and is no doubt one reason of the excellent qualities of Mocha coffee. This method, however, is not generally adopted in countries where there is a high rainfall.

In Brazil the crop is gathered "da terra" or "do lençal." If the first method is adopted the fruits are made to fall on the ground, which is first carefully cleared of weeds, and the cherries are afterwards gathered up and freed from sand, earth, etc., by sifting. In the alternative method the tree is shaken and the fruits collected on a cloth (lençal). Formerly this method was also practised at Santos, but since slavery was abolished in 1888 the gathering "da terra" (which is not so good, but requires fewer labourers) has gradually taken its place.

The fruits are usually carried in carts to the places where further treatment takes place, but on many large, up-to-date, plantations they are transported along galvanised iron spouting by the agency of running water.

Preparation for Market

The cherries as gathered each contain normally two seeds or coffee beans. Each bean is enveloped by the thin delicate silver skin, and outside this by the parchment, and both are enclosed in the fleshy pulp of the outer portion of the fruit. All these coverings have to be removed to prepare the beans for consumption. This may be done in one of two ways,



JAVA. COFFEE IN FULL FLOWER



NICARAGUA. DRYING COFFEE ON WOODEN TRAYS

(1) the older or dry method, still practised in Arabia and some other countries, and (2) the modern or wet method, often spoken of as the West Indian process.

The Dry Method of Preparation

The beans are spread out on stone drying grounds, commonly known as *barbecues*, in a layer a few inches deep. During the first day or two they are frequently stirred so that all are exposed to the sun, and afterwards means are usually adopted so that they can easily be removed under cover at night or at any other time when there is any chance of their being made damp again. The pulpy covering ferments and gradually dries, the whole processes taking two or three weeks. When thoroughly dry the beans can be stored any length of time until wanted, when all that has to be done is to remove the dried pulp in a primitive manner by pounding in a mortar similar to those used for husking rice (see illustration on p. 193), or, as is now more usual, in a hulling machine. In either case the dried covering is broken up and the beans set free.

The dry method, although it is simpler and requires less expensive machinery, is gradually falling into disuse, and even in Brazil, where it is still prevalent, it is losing ground, because the modern wet method is quicker and is independent of the continuance of settled fine weather over a considerable period.

The Wet Method of Preparation

In the "wet" method of preparation the cherries as brought in from the field are placed in a large tank full of water. The well-developed cherries are heavy and sink to the bottom, whence they are drawn off through pipes, whilst the immature and bad fruits (which are light) float on the surface, and are treated separately. The ripe cherries are carried directly to machines called pulpers.

Pulping. Pulpers are of various types, but one of the oldest, and yet most effective, consists essentially of a rough cylinder—more or less like a very large cylindrical nutmeg grater



OPEN-AIR DRYING OF COFFEE IN NICARAGUA

which is made to revolve facing a curved metal plate. Between the two there is not room enough to allow the cherries to pass. The cherries are reduced to a pulp by the rasping action of the revolving cylinder. The mixture of seeds and pulp is carried away into a vat full of water, where it is mechanically stirred to cause the seeds to separate from the pulp. The heavy seeds settle to the bottom whilst the lighter pulp is carried away by an overflow of water. The seeds or beans are drawn off and carried in a stream of water to a kind of sieve, and the water is drained away.

Fermentation. The beans are not yet clean, but the "parchment" which is still uninjured is covered with a slimy layer which cannot be got rid of in the pulping machine. To remove it the beans are placed in a cistern or vat. Fermentation is set up and allowed to continue from twelve to forty-eight hours or more. When the fermentation has proceeded for a sufficient length of time the beans are removed to another vat and washed.

Washing. This is sometimes effected by running in enough water to cover the beans and trampling on them with bare feet when the adherent tissue becomes loosened. Successive rinsings with water, stirring with rakes or by special machinery result finally in leaving the parchment coverings quite clean.

During the washing process those beans which are not developed sufficiently and are light float on the surface and are collected separately to be sold as "tailings" of inferior quality. When the washing is completed the beans are strained again and removed to the drying place.

Drying. This operation is carried out in much the same manner as the drying of cacao, the actual method adopted depending largely on climatic considerations. With an assurance of continuous sunshine and a dry atmosphere, it is sufficient to spread the beans out on a barbecue or drying floor usually made of stone, with a raised edge. By having sliding roofs to the barbecues, or by the provision of portable drying floors on rails, protection against rain

and dew is easily secured. Other planters use trays, which can be placed on supports above the level of the ground and readily carried under cover when necessary. Drying coffee in such trays is illustrated in the pictures on p. 189 and p. 190. When the sun's heat cannot be relied upon, artificial heat has to be resorted to. One method is to have special drying tables, fitted with steam pipes. The beans are spread on these tables or trays, constantly stirred, and rapidly dried by the application of heat which can be regulated as desirable.

The colour of coffee, which has such great influence on the market price, chiefly depends on the quantity of water which the beans contain. Blue beans contain more moisture than the green, and these again more than yellow ones, while slow drying in a damp atmosphere gives the beans the colour of lead.

The dried beans are now in the state known as "parchment coffee." Each bean is still covered by the delicate silver skin and that again by the parchment which is harder and stronger in Liberian than in Arabian coffee. The produce is frequently exported in this state, and, for some time at any rate, its quality appears to improve whilst it is kept in this condition.

Before, however, the beans can be used the parchment and silver skin must be removed, and this may be done on the estate, at the port of shipment, or at the receiving port or elsewhere, according to weather conditions, supply of labour, and other considerations.

Peeling. The removal of the final coverings is known as peeling. Machines of various types are employed, but in all the essential is to crack the parchment without injuring the bean. The coffee must be thoroughly dry before this is done, as then the parchment is brittle and more easily broken up, for example, by rollers. Winnowing removes the light pieces of parchment and leaves the heavy beans behind. A further simple rubbing and winnowing gets rid of the silver skin, leaving the beans clean and in the condition of ordinary unroasted coffee.



JAVA. STONE COFFEE DRYING FLOORS WITH MOVEABLE ROOFS

Sizing. To secure uniformity in size, which is desirable when roasting, the beans are sorted into large, medium and small by passing them through sieves with meshes of certain sizes. The last stage is to pick them over carefully by hand to remove all foreign bodies, broken or discoloured beans, and anything in fact which would lower the value of the product.

After the beans come on the market they only require roasting and grinding to be ready for use.

THE PRINCIPAL COFFEE-PRODUCING COUNTRIES

Brazil

The principal coffee-growing districts in Brazil are all included in the four states of Sao Paulo, Rio de Janeiro, Minas Geraes, and Espiritu Santo, lying just within the tropics, as shown in the map on page 177. It is recorded that in 1905 there were in the state of Sao Paulo no less than 16,615 coffee estates. The coffee-producing region is but a very small portion of



SURINAM. DRYING COFFEE ON PLATFORMS WHICH CAN BE RUN UNDER SHELTER

Brazil, which is nearly as large as all Europe, and much more coffee could be grown in the country if required. The consumption of the world, however, remains fairly stationary at about 16,000,000 bags (of 120 lb. each) per annum. All the other coffee countries put together produce about 4,000,000 bags, whilst for Brazil alone the crop for 1906 is expected to reach the enormous total of 16,000,000 bags, and some estimates put it as high as 18,000,000. The aim in Brazil now is rather to reduce the crop in order to maintain prices, and a tax has been imposed on new coffee estates. The present great production is largely due to the high prices which ruled from 1887 to about 1895, and encouraged planting enterprise. In 1901-2 the coffee crop of the world reached its maximum, and the lowest prices for the product were experienced in 1903-04.

Other South American Countries

In Venezuela and Columbia, situated in the northern and hottest portion of South America, coffee is extensively grown, chiefly in the mountain districts. From Venezuela the annual



export is worth about £1,500,000, and mostly goes to France, the United States, and Germany. The exports from Columbia are of much the same value, and the greater portion is taken by the United States.

Bolivia is sometimes allowed the honour of producing the best coffee in the world, that from the Yungas district being considered superior even to Mocha. Bolivian coffee is not important commercially, as the supply is not equal to the home demand. Ecuador and Peru both export coffee, and steps have recently been taken to develop an industry in Paraguay.



HULLING COFFEE IN JAVA

Central America

Guatemala is the most important coffee-growing country in this region, exporting coffee to the value of from £1,000,000 to £1,500,000 per annum. About one-half the crop goes to Germany. Coffee is the principal industry, and is estimated to afford employment to about half the population at crop time.

West Indies

The production in Jamaica is described on p. 195. Haiti is the principal coffee island of this group, producing coffee to the value of about £500,000 annually. In many of the islands coffee can be easily cultivated and is grown to some extent, if only for home consumption. Porto Rico formerly had a flourishing coffee industry, but its value has considerably



SORTING COFFEE IN MEXICO

diminished. Under the Government of the United States, experiments are being made to cultivate coffees of the type most in favour in the United States market, and to improve cultural methods. First-class Java coffees are being taken as the standard, and every effort is being made to obtain a product which can hold its own in competition with them.

Arabia

The name Mocha coffee is applied generally to the coffee produced in Arabia. The best portion of the crop goes to Turkey and Egypt, being purchased on the trees by traders who themselves look after the picking and preparation. The coffee which reaches Mocha for sale is that which is not considered worthy of purchase by those traders.

Dutch East Indies

The produce from Java, Sumatra, Celebes, and Borneo is known generally as "Java coffee," and the greater part comes from Java. The plantations are largely owned by the Government, and great care is taken in the cultivation and preparation. The best Java coffees are of very high quality.

COFFEE PRODUCTION IN THE BRITISH EMPIRE

The chief coffee-producing countries in the Empire are India, Jamaica, British Central Africa, Trinidad, and Ceylon. Small quantities of the product are grown also in Queensland, British Honduras, and Natal, whilst in almost every part of the Empire one or other species of coffee is cultivated for local use.

India

As might be anticipated from the fact that this country is the chief source of "British-grown" coffee consumed in the United Kingdom, and of some twenty per cent. of our total supply, India is the principal seat of coffee production in the British Empire. The most recent returns estimate the area under coffee cultivation in India as close upon 213,000 acres,

almost all in Southern India, and about one-half in Mysore. The general tendency appears to be to decrease the area under coffee in the country. The United Kingdom and France take by far the greater part of the coffee exported.

Jamaica

The "Blue Mountain" coffee of Jamaica is famous and commands higher prices than any other kind of coffee. It is grown at elevations between 3,000 and 4,500 feet on estates situated in the Blue Mountain range whence it derives its name, in a region where the climate is cool, and rain alternating with bright sunshine, is obtainable all the year round. The output of this better grade is limited to rather less than 8,000 cwt. per annum. The total export of coffee varies, however, between 50,000 cwt. and 100,000 cwt., and it usually stands about third or fourth in order of value amongst the products of the colony.

British Central Africa

Coffee is the principal export of British Central Africa, and the Protectorate stands alone in the British Empire in this respect. The introduction of coffee into the country is quite a recent event, comparatively speaking, having taken place in 1878. By 1886 coffee was by far the most important item in the list of exports. During the last ten years the value of coffee exported has been altogether about £242,000, whilst during the same period the total value of all exports—cotton, rubber, tobacco, and ivory, in addition to coffee—has been about £350,000.

The area under coffee reached its maximum in 1901, when it was 16,917 acres; it decreased more or less steadily, until in 1904 it was 8,867 acres. Last year there was a sudden drop to 4,880 acres. The diminution in coffee cultivation has been due to the general depression in the coffee market and locally to droughts to a considerable extent. The great fall between 1904 and 1905 appears to be due to the increased attention given to cotton. The coffee estates are chiefly situated in the healthy Shire Highlands, and Arabian coffee is almost entirely grown.



MEXICO. THE LAST EXAMINATION BEFORE SHIPMENT



ROASTING COFFEE

CEYLON

A quarter of a century ago coffee was the principal product of the colony, and the value of the annual crop exported exceeded £3,000,000. Now it is only about £25,000, whilst the tea occupies the premier position.

Coffee Leaf Disease. The Ceylon coffee industry was ruined owing to the attacks of a minute fungus, known as *Hemileia vastatrix*, very similar to the rust of wheat. The disease was first noticed in 1869, when it was already fairly well distributed throughout the island and had probably been in existence for some time. The characteristic outward sign of the disease is the formation of a number of yellow spots on the surface of the leaves. Owing to the fungus using up the plant's food, the coffee plant is weakened, its leaves fall long before they would if not attacked, only a small proportion of the flowers develop sound fruits, and accordingly a very poor crop is the result, whilst the whole plant is weakened and may finally be killed. The disease was very carefully investigated by the late Professor H. Marshall Ward in 1880-81, but no curative measures could be discovered. Coffee estates had to be abandoned, and many planters were ruined. Some tided over the crisis by cultivating cinchona (see Drugs), and, later, tea was actively taken up. The greatest assistance was rendered by the Botanic Garden, and the Ceylon planters displayed wonderful energy in meeting the disaster. Within a year or so after the disease was noticed in Ceylon it appeared in Southern India, and rapidly spread to other countries also, the spores probably having been introduced in various ways; practically all the coffee-growing regions of the Old World were affected. The disease is so dreaded that other countries took, and still take, every possible precaution to guard against its introduction.

THE PRINCIPAL COFFEE-CONSUMING COUNTRIES

First in importance are the United States of America, which import for home consumption about one-half of the world's commercial coffee crop. The average consumption per

head in the United States is very high, about 11 to 12 lb. per annum, which is equalled or exceeded only in Norway, Sweden, and Holland. We take the lowest position, the average consumption per head in the United Kingdom being less than 1 lb. per annum. Similarly in Canada, each individual uses on the average less than 1 lb. of coffee yearly, so that the relatively enormous consumption in the United States is rendered the more striking.

Germany follows the United States, using considerably less than one-half the total of the latter country, but then the individual consumption in Germany is only between 6 and 7 lb. per annum. France, Austria-Hungary, and Holland are next in order of consumption. Sweden, Belgium, and the United Kingdom form another little group, each taking about half the amount used in Holland or Austria-Hungary. In Sweden and Belgium there is a high individual consumption, whereas in the United Kingdom, as already noted, it is very low.

THE ACTIVE PRINCIPLE OF COFFEE

The stimulating and refreshing action of coffee is mainly due to the presence of caffeine and a volatile oil. Caffeine belongs to the group of substances known as alkaloids, which as a class have usually a bitter taste and are only slightly soluble in water. Amongst other well-known alkaloids are cocaine, the active principle obtained from coca leaves; morphine, codeine, and narcotine, the essential constituents of opium; quinine and cinchonine, to which the bark of cinchona owes its properties; theobromine contained in cacao. Theine, the alkaloid of tea, is practically identical with caffeine, and both are very similar to theobromine. Paraguay tea or Maté and kola nuts contain caffeine.

The quantity of caffeine present varies greatly in different species of coffee. It is never very large in amount, slightly under 2·0 per cent. of the dry seeds being the highest recorded. Analyses of Arabian coffee show a range of between 0·7 and 1·6 per cent., whilst Liberian coffee varies from about 1·0 to 1·5 per cent. The wild Sierra Leone coffee (*Coffea stenophylla*) contains about 1·5 per cent. Four species of coffee, natives of Madagascar or of the neighbouring islands, do not contain any caffeine.



From photo by permission of *Messrs. A. Duperly & Son, Kingston, Jamaica*

JAMAICA COFFEE TREE

COFFEE SUBSTITUTES AND ADULTERANTS

Various substances have been used as adulterants of, or substitutes for, coffee. In most instances the object is to increase the profits by selling at the price of coffee a much cheaper article.

Chicory

It is difficult to know whether chicory should be described as a coffee adulterant in all cases, because there are many people who prefer the addition of chicory.

Chicory is prepared from the fleshy roots of *Cichorium Intybus*, a plant closely related to the lettuce, and found wild throughout a great portion of Europe, North Africa, Siberia, and Northern India. In parts of the United Kingdom it is a conspicuous wayside plant with cornflower blue flowers. Chicory was formerly the basis of an industry of some importance in England, and at one time about half the chicory used in this country was produced at home. About 1860 over 1,500 acres were devoted to this crop in Yorkshire alone. Various circumstances, however, have effected a great reduction in the crop. The removal of protective duties in 1854, coupled with the imposition of excise duties from 1860 onwards, had much to do in bringing about this result. The total area under chicory in the United Kingdom is now only some forty acres, and the preparation of the roots is only practised at York and St. Ives. At the present time the home-grown article contributes merely about two per cent to the annual consumption, the great bulk of the imports coming from Belgium.

In addition to its legitimate use, chicory is often employed to adulterate coffee, and sometimes as much as ninety per cent. of chicory has been detected in ground "coffee." It must be remembered that whereas coffee is worth, say, about 1s. 6d. per lb., chicory costs only 4d. per lb. A simple test whereby to detect the presence of chicory is to put a little of the ground material in a glass of water. Coffee remains hard and floats on the surface for a long time; chicory soon softens, and sinks, colouring the water more or less brown.

Other Substitutes and Adulterants

The substances which have been found as adulterants in ground "coffee" are very varied, including cereals, sawdust, bark, cacao husks, acorns, figs, lupine, peas, beans and other pulses, and even baked liver. Colouring materials are also used to improve the appearance of poor and damaged beans. Artificial beans composed of such ingredients as flour, chicory and coffee, or bran and molasses have been manufactured, the mixture being ground up, made into a paste, and moulded into the form of the genuine article.

A few seeds make a palatable infusion with water and are used to some extent as substitutes for coffee, although they lack its stimulating properties. One of the best known is Negro Coffee, or Mogdad Coffee, the seeds of *Cassia occidentalis*. The seeds of a species of Ipomea, the ochro (*Hibiscus esculentus*), and the soja bean are also employed for the same purpose.

TOBACCO

Tobacco is prepared from the leaves of several species of Nicotiana, a genus of plants belonging to the natural order *Solanaceae*, a family which includes the tomato, potato, egg-plant, deadly nightshade, and many other well-known plants.

The species of Nicotiana are numerous, but those of which the leaves are used as tobacco are very few. The great bulk of the world's supply of tobacco is derived from *N. Tabacum*.



PACKING CIGARETTES IN HOLLAND



CLEARING THE FOREST FOR TOBACCO IN SUMATRA

which is very largely cultivated in the United States, Cuba, the Philippines, and also in Holland, Germany, France, and some other countries. It is a handsome plant, the upright unbranched stem reaching a height of from three to six feet or more, and bearing large, pointed, oval leaves, which at the base of the stem are slightly stalked while those towards the upper part are without stalks and clasp the stem. The pink or rose-coloured flowers are funnel-shaped, and borne in a branched inflorescence at the top of the stem. The whole plant, with the exception of the flowers, is viscid to the touch, due to the occurrence of soft hairs which secrete a resinous juice from the cells at their apex.

East Indian, or Green Tobacco, is obtained from another species of Nicotiana, viz., *N. rustica*, originally a native of Mexico, but now extensively cultivated in Southern Germany, Hungary, and the East Indies. The plant is smaller than the preceding, with a much-branched stem, but grows more quickly, and not only ripens earlier, but is more hardy. The flowers are greenish or pale yellow, and the leaves are shorter and broader in proportion than those of the American plant. While *N. Tabacum* produces the various grades of American and Turkish tobaccos, and also the famous Latakia variety, *N. rustica* is the source of the Hungarian tobaccos, and also affords much of the East Indian leaf. the opinion of many connoisseurs, the finest tobacco in the world is the Persian variety, known as Shiraz tobacco and this again has an origin different from either of the two mentioned above, the plant concerned being *N. persica*.

It must not be supposed that the species of Nicotiana cultivated for tobacco exhibit no variation in botanical characters when grown in different parts of the world, for the first two species mentioned above possess numerous varieties; but in the two species *N. Tabacum* and *N. rustica* and their many varieties, and perhaps *N. persica*, (which is regarded by many authorities as a mere variety of *N. Tabacum*), we have practically the only members of the large genus Nicotiana, which are the sources of commercial tobacco. *N. repanda*, however, is said to have formerly furnished some of the best cigar tobaccos of Cuba, and *N. latissima* is



BUFFALO PLOUGHS AT WORK ON A SUMATRAN TOBACCO FIELD

reported to yield the variety known as Orinoco. The subject of the botanical source of the chief commercial tobaccos will be more fully dealt with later.

The question as to the original home of so important a plant as tobacco—using the term to include the three species mentioned—is naturally one of very great interest, and has given rise to a considerable amount of discussion. Briefly stated, the question resolves itself into deciding between the claims of the Old and the New World as the home of the plant which is now equally common in both. For a very long time, indeed up to the middle of last century, it was by no means certain that truly wild plants of at any rate *N. Tabacum* had ever been gathered in America by botanists, and Flückiger and Hanbury in their great work on the History of Drugs stated that "the common tobacco is a native of the New World, though not now known in a wild state." Later, however, evidence was forthcoming for the occurrence of the plant in the wild condition.

With regard to *N. rustica*, many botanists have been inclined to ascribe to this plant an Eastern origin, and the plant most certainly has the appearance of being perfectly wild in many districts of the Old World. But authors of the sixteenth century spoke of this species as a plant introduced from foreign countries, and there can be little doubt that its occurrence under apparently perfectly natural and wild conditions is due to its escape from cultivation. The evidence for a non-American origin of tobacco appears, therefore, to be of a very slight character, and De Candolle sums up the question in characteristic fashion. He finds that of all the numerous species of the genus Nicotiana found in a wild state, only two are foreign to America, and both of these occur in Australasia: *N. suaveolens* of Australia, and *N. fragrans*, found in the Isle of Pines, near New Caledonia. Further, in the contention that all Eastern peoples are great lovers of tobacco, and have indulged in the habit of smoking from very early times, he finds no support for the Asiatic origin of the tobacco plant, for the narcotic "smoked" was quite different from tobacco and was derived from a variety of plants, one of the most commonly used being "bhang," the dried leaves of Indian hemp (*Cannabis sativa*). Again, the writings of travellers in the East up to the thirteenth and fourteenth centuries make no mention of tobacco and, in fact, we are in possession of no certain evidence concerning the use of tobacco in Asia until the seventeenth century, *i.e.*, until after the introduction of the plant into Europe. Taking, therefore, these facts into account, we are forced to the conclusion that tobacco reached the East via Europe, *i.e.*, ultimately from America.

Evidence of a very valuable kind in determining the home of a plant is afforded by a study of the names under which the plant is known in different parts of the world. If a plant has a wide distribution and has been known in different countries from the most remote times, it will almost certainly receive names which etymologically are distinct. Now in the case of tobacco, the plant is known throughout the New World by names which can be very readily recognised as mere corruptions of "tobacco," a word which, as we shall see later, is of undoubted American

origin. The evidence afforded by this line of reasoning, therefore, points to the general introduction into the New World of a plant which was already recognised under an accepted name, and this name was that under which the plant was received in Europe from America.

The only remaining point for us to consider is the validity of the statement which ascribed two indigenous species of Nicotiana to Asia, viz., *N. forstica*, to which we have already referred, and *N. chinensis*, which was stated by the Russian botanist Fischer to be of Chinese origin. The former is in all probability a variety of a Brazilian plant, which must have been introduced into Persia by seed, and the latter has proved to be merely *N. Tabacum*.

Summing up, then, we find that, in all probability, there are no truly Asiatic species of Nicotiana, which is a typically American genus, and the only two species occurring outside the Western hemisphere are *N. suaveolens* and *N. fragrans*, both of which are found in Australasia.

The origin of the word "tobacco" has given rise to a certain amount of discussion. One view inclines to the belief that the word is derived from the island of Tobago, in the West Indies, the chief evidence in support of this opinion being that, when in 1520 Ferdinand Cortez gained a great victory in this island he found extensive plantations of tobacco in several districts. The plantations, however, were no larger than others which had been previously noted in other parts of America, and there seems no reason to regard Tobago as the home of tobacco, from which the herb received its name. Benzoni, an early American explorer, states in his "Travels in America" (1542-1556) that the native name of the plant in Mexico was "tabacco." There seems to be little doubt, however, that the true origin of the word as it was received in Europe was derived from the name of a peculiar piece of apparatus used by the natives of San Domingo in smoking the herb. When the Spaniards visited this island in the early years of the sixteenth century, they found the people inhaling the fumes of burning tobacco through a double pipe which was inserted in the nostrils. The "pipe" was of narrow diameter and Y-shaped, the arms of the Y being sufficiently close together to be held in the nostrils with comfort, while the leg of the instrument was held in the fumes of tobacco which were thus drawn up into the nose and inhaled. This "pipe" was called by the natives "tabaco," and there is little doubt that in it we have the origin of our "tobacco." It should be noted that the smoking pipe of the Indians of the American mainland was quite different from the tabaco, and corresponded, roughly speaking, to the modern type.



PLANTING UP NEW LAND IN TOBACCO

The Discovery of Tobacco by Europeans

Having thus briefly dealt with the botany and probable origin of the tobacco plant, we will now turn our attention to some of the chief points in connection with the introduction of tobacco itself into the countries now mostly addicted to its use. As has been stated above, the practice of resorting to the inhalation of narcotic fumes in order to allay excitement and to produce a pleasant general sense of comfort has long been known among Eastern people. Thus we have mention of the practice in the writings of Herodotus, and the habit was known among the ancient Gauls, who employed hemp for the purpose.



BRITISH NORTH BORNEO. YOUNG TOBACCO PLANTS UNDER SHADE

The first trustworthy mention of tobacco as the narcotic employed was made by Christopher Columbus. In the latter part of 1492, Columbus despatched a small expedition from among his ships' crews to explore the island of Cuba, and the men, on their return, reported that the inhabitants of the island perfumed themselves with a certain herb from which they drew clouds of smoke. The herb was dried and rolled in a piece of maize-leaf, which was lighted at one end and held in the mouth at the other, a description which would be roughly accurate for a modern cigarette or cigar. During his second voyage to America in 1494-6, Columbus was accompanied by Ramon Pane, a Franciscan monk, who describes the habit of snuff-taking among the Indians, and later the Spaniards observed the practice of tobacco-chewing among the natives of South America. As the Spaniards penetrated into the new countries it became more and more obvious that these practices, especially that of smoking, which up to the present had been probably regarded as mere local customs, were an ancient and universal usage; and later exploration and study showed that they were intimately bound up with the most solemn rites and ceremonies of the native peoples. Other explorers, following

in the footsteps of Columbus, realised the importance of [illegible] and its probable [illegible] properties, and in this connection mention must be made of the names of Petrus Martyr and the famous Milanese, Girolamo Benzoni. It fell to the lot of Francisco Fernandez, however, a physician commissioned by Philip II of Spain, to enquire into the economic possibilities of the flora of Mexico, to introduce the plant itself into Europe in 1558. Both plants and seeds were sent to Spain, where it is reported that the plant was much admired on account of its beauty. For some considerable time tobacco was regarded as a medicinal herb only, but its value in this respect was held in the highest esteem, largely owing to the writings of Nicolo Monardes, a famous Spanish physician. The plant was credited with almost miraculous powers, and at this time attained an extraordinary degree of popularity as a medicine: the most wildly enthusiastic names were ascribed to it, some of the most common being "herba santa," "sana sancta Indorum," "herba panacea," etc. Even in our own country Spenser later describes it as "divine tobacco," and William Lilly as "our holy herb nicotian." Much of the rapid increase in the popularity of the plant on the Continent was due to the efforts of the French ambassador at the Court of Lisbon, Jean Nicot, and so great were his efforts in this direction that they have been commemorated in the name of the genus Nicotiana. Nicot, on his return to France from Lisbon, took from the Royal Garden at the latter city a plant of tobacco which he presented to Francis II and Catherine de Medicis, recommending it as a drug of great value, and this plant together with others which were forwarded to Nicot from Lisbon soon after his return were the first to be introduced into France.

While tobacco thus became introduced into Europe through Spain, and the medicinal properties of the plant was clearly recognised by the physicians of that country, it appears that it fell to Englishmen to introduce the habit of smoking the herb to the inhabitants of the New World. When in 1586, Ralph Lane, the first governor of the new English colony of Virginia, and Francis Drake returned from that colony they brought back with them the cured tobacco leaf for smoking, and, in addition, certain pipes and apparatus used in the process. The tobacco and implements were handed over by them to Sir Walter Raleigh. There seems to be some difference of opinion as to who was the first Englishman to seriously adopt the new habit, but the honour is generally ascribed to Ralph Lane himself, and the stories of the first finding of Sir Walter Raleigh smoking by his servant, and the statement that he "tooke a pipe of tobacco a little before he went to the scaffolde" are too well known to need more than passing mention. No sooner had the custom of smoking become seriously



A TOBACCO FIELD IN SUMATRA

adopted by a few individuals than it spread with marvellous rapidity among all nations, the most rapid strides in the spread of the habit taking place during the seventeenth century.

The rapid increase in the use of tobacco was viewed by the authorities, and especially by the priestly classes, with the greatest concern, who saw in the habit the final complete demoralisation of the people. Even in our own country, in spite of the praises of the poets, the divines bitterly denounced the new herb which rapidly gained popularity among all classes of the people, notably among the soldiery. Strong as the opposition to tobacco was in England, the vehemence with which it was opposed was as nothing compared to the drastic measures taken for its suppression on the Continent, and it will be of interest to note the rise of the use of the fragrant weed in the chief countries of Europe.

The practice of smoking tobacco did not become general in France until the reign of Louis XIII, when the habit took a great hold upon the people, even women smoking. So great a hold, indeed, that the Government, with possibly more than one object in view, thought fit to levy a tax upon all tobacco imported from America. The people, at first, smoked small pipes with a metal bowl fitted with an oaten straw stem, the model being copied from the pipes introduced from Spain; but very soon it became the fashion to smoke tobacco in pipes of the elaborate design used by the Orientals for their bhang and opium. It was not long before a heated controversy arose between the people on the one hand and the scholars and physicians on the other as to the morality of tobacco smoking, but the habit grew so rapidly among all classes and the national exchequer was benefited to so great an extent that before long tobacco received royal support, and Louis XIV directed that all his troops, then being despatched on an expedition to Holland, should be provided with tobacco and pipes.



A CUBAN PLANTATION

Among the upper classes smoking did not become so popular, tobacco being taken more generally in the form of snuff, and, in consequence of this, it was about the end of the seventeenth century that the craze for expensive snuff-boxes set in.

The actual date of the introduction of the fragrant weed among that nation of smokers, the Dutch, is somewhat uncertain. In 1590 the physician William Van der Meer wrote that he had seen English and French students smoking the new herb at Leyden, but there is some reason for supposing that the habit had been indulged in by Dutch sailors some years previously. Nevertheless, smoking does not seem to have made any great progress amongst the people at this time, and, indeed, we read that for some years after the preliminary attempts of the students and seamen, tobacco was relegated to the chemist's shop, where, however, it held



A FIELD OF RIPE TOBACCO

a wonderful reputation as a panacea. In the beginning of the seventeenth century the use of tobacco again became general, and soon attained great popularity. The leaf was imported into Holland from the West Indies in relatively large quantities "so that soon over a hundred thousand guilders were paid in Holland for tobacco every year." So great a hold did tobacco obtain over the people, that in 1615 plantations of the plant were actually laid out near Amersfoort and Zeeland, and soon afterwards the inhabitants of the Gelderland, Utrecht, Noord-Brabant, and Limburg provinces followed suit. Every day new "tobacco houses" or taverns were opened in the towns, where tobacco leaves were retailed by women to the men who sat round the fires and tables of the house cutting up the tobacco and smoking it in their clay, tin or silver pipes; needless to say, the convivial glass was not without its place at these gatherings, and soon all classes, both rich and poor, spent a considerable part of their leisure indulging in the new habit.

It was at this stage that active opposition to tobacco began to make itself felt in Holland. The General and Provincial Governments attempted to check the habit by the issuing of severely worded proclamations and the imposition of heavy duties: the municipal authorities imposed fines on persons found "sucking" tobacco; the governors of orphan asylums and religious institutions forbade tobacco-smoking under pain of instant dismissal or even imprisonment; and finally, it was made impossible for the country's military and naval defenders to obtain any of the weed at all. Nevertheless, in spite of all efforts by well-intentioned people to the contrary, smoking spread with great rapidity among all classes.

The importance of the tobacco trade to Holland grew rapidly, and at the beginning of the

eighteenth century had reached considerable dimensions, for not only was the Dutch market itself of great value, but the geographical position of the Dutch ports and the flourishing condition of her mercantile marine rendered Holland a very convenient distributing centre for the principal smoking countries of Europe. Large quantities of leaf were imported into Amsterdam from Virginia, and soon supplies came also from the West Indies—Jamaica, St. Vincent, Antigua, Dominica, Cuba, and Brazil. Further, the home cultivation of tobacco rapidly increased and, before long, practically every suitable area in the Utrecht, Gelderland, and Amersfoort districts was planted up in tobacco. It was not long, however, before the inevitable reaction set in, and in a very few years large numbers of the tobacco merchants and planters were ruined. This *debâcle* was not the result of decreased consumption, but was the natural consequence of over-production, deterioration in the quality of the article supplied, and excessive competition, the latter being especially encountered at the hands of the merchants of Bremen who were now also endeavouring to share in the import trade. Further, the German states at this time levied heavy import duties on Dutch tobacco, and, when similar imposts were made in Belgium, two of the most important of the Dutch markets were closed. By 1760, however, the trade had somewhat revived, and during the American War of Independence the stoppage of supplies from Virginia led to a great impetus being given to the home plantations.



HARVESTING THE LEAF

It would be difficult to find more confirmed smokers than the Germans, and after its introduction into the country in the sixteenth century, the use of tobacco spread with extraordinary rapidity among the people. Neiner says "from the moment they (*i.e.*, the people) made the acquaintance of tobacco, the habit of smoking spread so rapidly that there was no farmer's cottage where the tobacco pipe was not found; they sometimes smoke the herb, sometimes chew it, and sometimes use it as snuff, and we can only wonder that it has not occurred to anyone to put it into his ears!" At the magnificent Court of Frederick I tobacco was smoked, and after the Seven Years' War, Frederick II, one of the greatest users of snuff of his time, tried all means in his power to foster the cultivation of tobacco in his dominions: he consulted the most celebrated botanists and chemists as to the best methods of procedure, and followed the example of France, Holland, Spain, and other countries, in establishing tobacco culture as a prerogative of the Crown.

The measures adopted for the suppression of tobacco-smoking were exceedingly drastic in several continental countries. In Russia the herb was solemnly cursed and declared unclean by the ecclesiastical authorities, and in 1630 its use was forbidden by royal proclamation.

THE WORLD
The Tobacco Producing Countries
Steamer Routes
NORTH AMERICA
SOUTH AMERICA
AFRICA
AUSTRALIA
ASIA
EUROPE



TOBACCO GROWN FOR SEED PURPOSES IN SUMATRA

The people, however, disregarded the patriarchal ban and the orders of the "Little Father," with the result that three years later smoking was forbidden under the penalty of losing one's nose. Even this vigorous measure failed in its object, and, in 1641 the Czar Alexis ordered that, on the third conviction for smoking, the offender should have his nostrils split and be banished to Siberia for life. Many paid the penalty, but smoking became more and more popular—so popular, indeed, that several fires in Moscow were directly traced to the users of the weed. This was the last straw, for, fearing a disastrous conflagration in his capital, the Czar, in 1655, absolutely prohibited smoking under penalty of death. In the reign of Peter the Great, however, a great change of opinion took place, and smoking was openly encouraged by the Crown in spite of the prohibitions of the Church. Since that time smoking has steadily increased in the country, and at the present time Russia is one of the chief tobacco-producing countries of the world.

The Botany of Tobacco

We will now consider, in somewhat greater detail, the species of Nicotiana of value to the tobacco manufacturer, and the classes of tobacco which are prepared from them. Probably the most important is *N. Tabacum*, variety *macrophylla*, which produces the Maryland tobaccos. There are two kinds, the Stalkless Maryland, which yields a good smoking tobacco and excellent material for the outer "wrappers" of cigars, and some of its forms, especially those cultivated in Germany and Holland, are especially adapted for snuff manufacture. The other kind is the Stalked Maryland, which produces a very fine leaf from which probably the finest Turkish tobacco is obtained. Much of the Cuban and Manilla tobacco is regarded as derived from this variety.

We then have another variety of *N. Tabacum*, viz., var. *angustifolia*, so called on account of its comparatively narrow leaves. This is the source of much of the Virginian tobacco, but large quantities of snuff are also prepared from this variety which is cultivated to a considerable extent in Germany and also in the East Indies.

The world-famous Latakia and Turkish tobaccos are now generally regarded as obtained from a variety of *N. Tabacum*, though formerly they were ascribed to *N. rustica*.

The latter species is the source of Hungarian, Brazilian, and much Asiatic tobacco, and some of its varieties, especially the narrow-leaved Hungarian form distinguished as *N. rustica*, var. *ovata*, afford good smoking tobacco, although the yield is comparatively small.

N. crispa is the source of the tobacco used in making the famous cigars of the Levant, and is largely grown in many parts of Asia Minor and also in Central Asia. Shiraz tobacco, as stated

above, is derived from *N. persica*, but botanists are now inclined to regard this so-called species as a mere variety of *N. Tabacum*, and so we must accredit this latter plant with one more famous tobacco.

The Commercial Classification of Tobacco

In spite of the interest which attaches to a knowledge of the botanical origin of the principal types of tobacco, the fact remains that such a knowledge is of little use to the tobacco manufacturer, for the number of varieties and form of the chief species is so great that it is a matter of the greatest difficulty to trace any particular grade to its botanical origin: and further, the very same variety of tobacco grown on the same plantation for two consecutive seasons may produce a leaf which is adapted for entirely different purposes. In the first year the variety may yield comparatively thin and dry leaves, which are only useful for cigarettes; while, in the next season, the same variety will produce a heavy leaf suitable for the "wrappers" of plug tobacco. The same plant will also produce several different classes of leaf; thus the upper leaves will afford a cheap variety of pipe tobacco, the middle leaves a plug wrapper, and the lower leaves a good quality of smoking tobacco.

For this reason the tobacco dealer disregards all botanical and cultural classifications when dealing with the prepared leaf, and adopts a system of his own. Tobaccos are first of all divided into "classes," a "class" signifying the purpose for which the product is finally intended. Thus, we have the pipe, cigar, chewing, and cigarette classes, and these are again subdivided into various "types," a classification depending on the combination of certain qualifications of the leaf such as colour, flavour, elasticity, and strength, or on certain characteristics produced by the different methods of curing the leaf, *e.g.*, air-cured or sun-cured. We then have a further subdivision into "grades," which are almost endless in variety, depending upon the different degrees of size, aroma, texture, possessed by the leaf.

When we are told that it is possible to grade a parcel of Sumatra tobacco from the same field into no fewer than seventy-two grades, it will be realised that such a classification



SUMATRA. CHINESE COOLIES BRINGING IN THE LEAF FOR INSPECTION

can only be performed by men who have spent their whole lives in the trade. Mr. G. S. Odlum, of the Department of Agriculture for Southern Rhodesia, has summed up the matter in the following words: "To become expert in the classification and grading of tobacco requires life-long experience. All that the farmer can attempt to do is to place all leaves of a certain size, quality, and colour together, and let the buyer classify them as he wishes. This proper assortment of the leaf is one of the most important things in the whole of the tobacco business. A few leaves placed in the grade above where they belong will largely destroy the selling value of the whole grade, and in case of doubt always place the leaf in the grade below. Many farmers do not receive more than from one-half to three-quarters of the value of their crop, for the reason that they have neglected to properly classify and grade their tobacco, and hundreds of shrewd leaf dealers have made their fortunes by buying up this poorly graded tobacco and re-grading it."



CUBA. CURING THE LEAF IN THE OPEN AIR

A "Good" Tobacco

To attempt to define a "good" tobacco, or even to enumerate its characteristics, would probably be regarded as presumption by the average smoker, for each individual consumer of tobacco is a law unto himself on this important point! And to a very great extent he is quite right in his contention, for a tobacco regarded as ideal by one man is quite unpalatable to another. Persons leading a sedentary life generally prefer a "mild" tobacco, while those engaged in active out-door employment are generally not content unless provided with a strong tobacco, and it is a matter of common experience with sedentary workers to find that, during a prolonged holiday, in which they enjoy abundance of active physical exercise, a strong tobacco which would have been refused by them under ordinary conditions, is consumed with comfort.

In the early days of the tobacco habit there can be little doubt that any tobacco which would burn readily was considered suitable for consumption, and from the quality of the leaf still used by many of the poorer and more primitive peoples of the world it would seem that the idea is by no means extinct. The modern civilised smoker, however, demands a product of good quality, and although the choice of a suitable tobacco is largely a matter of individual taste, there are certain points upon which probably all smokers would agree.

One of the most important characteristics of a tobacco is its flavour, a point of the utmost importance when considering the suitability of any variety for cigar manufacture, and by no means to be disregarded in the matter of pipe and cigarette tobaccos. The flavour must be sweet and pleasant, and neither too mild nor too strong. In the manufacture of the best cigars great care is taken to select tobaccos of good flavour for the body or "filler," and at the present day the finest fillers are obtained from the Vuelta Abajo leaf, which is cultivated

with great care in Cuba. The outer wrapper of the cigar is also obviously of great importance, and for this purpose the standard of excellence is the Sumatra leaf, so largely cultivated in the Dutch East Indies, and also in the United States. It is desirable that the wrapper leaf should be as free from flavour as possible, since it comes into actual contact with the lips and tongue of the smoker, but it must possess a light and uniform colour, be thin and elastic in texture, and the veins of the leaf must be small and comparatively inconspicuous. The burning qualities of a tobacco are also of great importance. It must burn readily and yet



THE INTERIOR OF A CURING BARN

evenly, quietly and completely so that no half-burnt "char" is left, and if the tobacco is intended for cigars the ash must be white and of sufficient tenacity to prevent it breaking readily and spoiling the clothes of the smoker.

A chewing tobacco must possess qualities which would render it quite unsuitable for the purposes of pipe or cigarette smoking. It must be very rich in flavour, and, what is of almost equal importance, the leaf must be of a high absorptive capacity, for no small part of the high flavour of such tobaccos is produced by the addition of artificial flavouring matters which are added to the leaf in the form of a liquid or extract known to the trade as a "sauce." Another important point in chewing tobacco is its degree of toughness, for any leaf which would readily break or powder while being masticated would obviously be of little value; closely connected with the toughness is the degree of "gumminess" which is so much sought after for this class of tobaccos. It should be noted that this last-mentioned property is one which must



INTERIOR OF A FERMENTATION HOUSE IN SUMATRA

be quite absent from leaf intended for pipe or cigarette tobaccos, since the gum would seriously interfere with the cutting of the leaf when placed in the machines.

As might be suspected, it is not often that a single tobacco possesses all the desirable properties demanded by both the manufacturer and the consumer. In fact, it is very seldom that such an ideal leaf is met with, and it is necessary to blend or mix different grades until a satisfactory article is obtained. Several motives induce the manufacturer to blend his tobaccos extensively. Much of the mixing is, as just stated, carried out with the object of producing as perfect a tobacco as possible, or one to meet the requirements of special tastes. On the other hand, it is a very common practice to add a comparatively small proportion of an expensive, first-class, and highly flavoured tobacco, such as Perique, to varieties which are deficient in desirable qualities, with the result that a perfectly satisfactory article of medium quality is obtained. No small part of modern blending, however, is the direct result of the caprice of the taste of the consumer. Fashion plays a considerable part in the choice of tobaccos, and constitutes one of the many difficulties which have to be met by the manufacturer. Should the latter place upon the market brands of tobacco which consisted of one variety only, it would be highly probable that, should that particular variety of leaf become scarce at any time, the substitution for it of a different variety would ruin the reputation of the brand. To avoid this undesirable state of affairs, the manufacturer places upon the market brands which are largely blended from various tobaccos—as many as five different varieties being sometimes used—in order that, should any particular leaf become scarce, the substitution of another variety will not be markedly noticeable.

Although individual taste with regard to tobaccos varies considerably with different persons, it is nevertheless a fact that definite types of tobacco are demanded by different countries and that a variety suitable for one country would be quite rejected by another.

Great Britain demands, on the whole, the best qualities and most highly priced leaf, and is one of the most valuable markets for the products of the United States, the average annual import from America being nearly 93,000,000 lb. of leaf. She is buying more and more of the better grades of tobacco, and is rapidly increasing the consumption of the lighter shades of tobacco known in the trade as Bright Leaf. The strongest tobacco imported is that intended for the manufacture of Navy plug, but the most important is a "smoked," somewhat olive-coloured leaf. In former days it was necessary to have a "smoked" tobacco in order to withstand the long sea transit, and the taste for such tobacco then acquired has maintained its hold upon the British consumer.

The total imports into the United Kingdom now average considerably over 100,000,000 lb. per annum, and the amount has more than doubled during the last fifteen years. The principal sources of our tobacco are the United States (including trans-shipments from Cuba and Porto Rico) with nearly 86 per cent. of the total supply, followed at a very long distance by Holland (chiefly from her colony of Sumatra) with only 5·1 per cent. Then comes Turkey with 1 per cent., and from British possessions, chiefly North Borneo, we receive 0·8 per cent. All other countries send approximately 3,000,000 lb., or roughly 3 per cent.

The German demands tobaccos which in many instances closely resemble those imported into England. The leaf must be stout, with plenty of body, and must be rich in oil: the colour most in favour is a dark red. Large quantities of tobacco are imported into Germany for trans-shipment to many parts of the Continent, notably to Russia, Norway, and Sweden.



CARRYING TOBACCO ALONG THE LANGKON ROAD IN BRITISH NORTH BORNEO

The supplies chiefly come from the United States to the extent of some 40,000,000 lb. per annum, and most of the Brazilian crop is also handled by the German dealer. The bulk of the French imports consist of the poorer qualities of leaf, but the Swiss, on the other hand, will only take the very best grades, which are mostly used for the wrappers of cigars; the quantity taken, however, is comparatively small. Italy and Austria import good qualities of tobacco, the latter country requiring a cigar-making material. The tobaccos sent to Spain are, generally speaking, very poor.

It will come as a surprise to most people to learn that, with the exception of the Russians, the British consume less tobacco per head than any other of the principal peoples of the world. The fact, however, remains, for while we use but 2 lb. per head per annum, the Belgian smokes no less than 6¼ lb., and our American cousin requires 5½ lb. a year. The following figures will show the relative positions of the chief countries.



TRANSPORT OF MEXICAN TOBACCO

Country.	*Average annual Consumption per head.*
Belgium	.. 6·2 lb.
United States ..	.. 5·4 „
Germany	.. 3·4 „
Austria	.. 3·0 „
Australasia ..	.. 2·6 „
Canada	.. 2·5 „
Hungary	.. 2·4 „
France	.. 2·2 „
United Kingdom ..	.. 1·9 „
Russia	.. 1·1 „

The Chemistry of Tobacco

The active principle of tobacco, and that which is chiefly responsible for its narcotic properties, is a liquid volatile alkaloid known as nicotine. It varies in amount in different tobaccos, the finer qualities containing comparatively little and the coarser sorts up to as much as seven per cent. Nicotine determines to a very large extent the strength of a tobacco, but its aroma and flavour are due to the essential oils of the leaf and also to the aromatic substances produced in the curing and "fermentation," which will be described in detail later. In addition, tobacco contains resins, fats, and certain organic acids to which must be added the ash constituents.

Nicotine is extremely poisonous, but in all probability it is in great part destroyed during smoking, the poisonous properties of tobacco smoke being due to the products of destructive distillation of this and other bodies during the combustion of the tobacco.

As regards the physiological effects of tobacco-smoking considerable difference of opinion exists. It is certain that it affects different people in different ways, and for young people there can be no doubt as to its harmful effects. For adults, however, it is not improbable that the habit has no harmful results if indulged in moderation, but it entirely depends upon the physical constitution and state of health of the individual concerned.



LOADING BALES OF TOBACCO INTO RIVER BOATS IN SUMATRA



STRIPPING THE LEAF

THE WORLD'S PRODUCTION OF TOBACCO

The five most important tobacco-producing countries, in order of their importance, are the United States, India, Cuba, Russia, and the Dutch colonies in the East, more especially Sumatra.

Nearly seven-ninths of the world's total tobacco is raised in these countries. Taking an average of the last few years, the total annual production of tobacco is considerably over a million tons, with a value of nearly £40,000,000 sterling! The following table will show at a glance the principal producers and the value of the tobacco grown :—

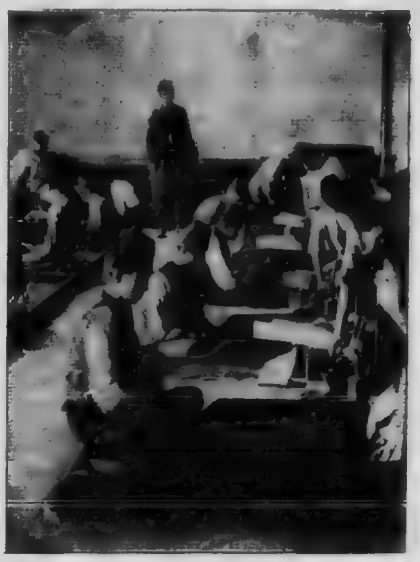
Country.	*Value.*
United States ..	..£11,900,000
India .. (approximately)	5,700,000
Cuba	3,570,000
Russia	3,500,000
Sumatra, Java, etc. ..	3,450,000
Germany	1,900,000
Brazil	1,250,000
Japan	900,000
Hungary	817,000

Country.	*Value.*
Turkey	£750,000
France	600,000
Philippines	540,000
China	(?) 470,000
Argentina	300,000
Porto Rico	250,000
Mexico	250,000
British North Borneo ..	176,000

In addition to the above, smaller quantities of tobacco are raised in Italy, Roumania, Canada, Greece, Belgium, Ecuador, Algiers, Egypt, and in several of the British colonies, notably Jamaica, British Central Africa, Rhodesia, Transvaal, and Uganda.

CULTIVATION IN THE UNITED STATES

Although tobacco had long been grown by the aborigines of the American continent, it was not until 1610 that the first European plantation was laid out near Jamestown, in Virginia. The cultivation was taken up with energy by the colonists, and before long tobacco was being grown in several states, notably in Maryland and Virginia; and for more than two centuries the industry was closely bound up with the social and political development of the States concerned. In Maryland tobacco was actually made legal tender in 1732, at the rate of one penny per pound, for all debts, including the salaries of State officials and clergymen. The industry was very early started in Pennsylvania, but comparatively little

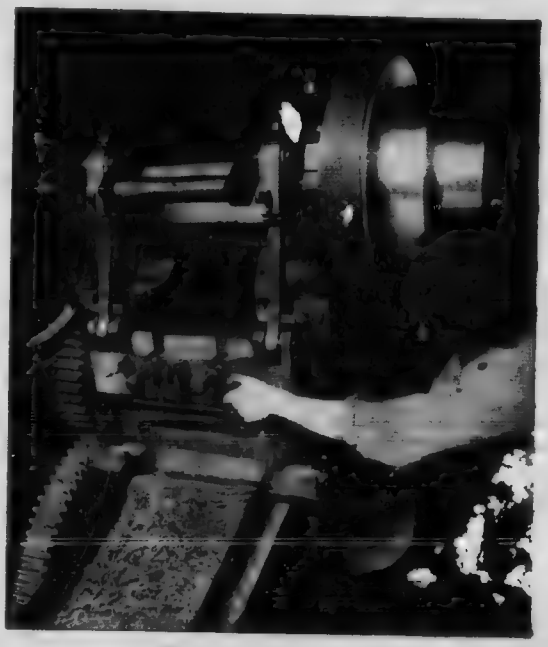


CUTTING TURKISH TOBACCO BY HAND

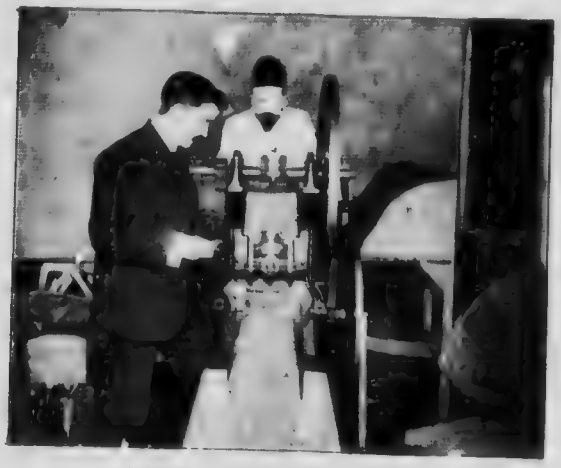
attention was given to it until 1828, when tobacco-growing was placed upon a firm footing. The first real extension of the industry, however, was westwards, in the States of Kentucky and Tennessee. By 1875 it had assumed considerable proportions in the northern parts of the former State, and in 1810 large areas were under tobacco in all parts of both States, the produce being sent to New Orleans for shipment.

In 1838 cigar tobacco was first grown in Ohio from seed obtained from Connecticut, where the industry had already attained considerable proportions. Seven years later the industry was started in New York State, and in ten years the yield had amounted to more than half-a-million pounds. The history of the tobacco industry in Florida is very interesting, and affords an excellent example of a successful attempt on the part of agriculturists to meet the altered requirements of the market. The cultivation of tobacco was commenced in the earlier years of the nineteenth century, and the leaf produced, known as "Old Florida," was of such fine quality as to be eagerly sought after as a wrapper for cigars. The industry thrived until the Civil War, when the cultivation had perforce to be abandoned, but when the country had settled down a few farmers continued to grow tobacco in a very small way, so small that in 1880 the State had but 90 acres under the crop. The industry again revived in 1889, and the planters naturally turned to their famous "Old Florida." But the demand of the market had changed, and cigar-makers now required tobaccos resembling the Cuban varieties for the "fillers" of their products and leaf of the Sumatra type for the wrappers. In 1884-5 some of the planters had obtained seed from Cuba and the tobacco grown from the seed was sent to the dealers at New York, who made it into cigars. The quality of the cigars was so satisfactory that experts were at once sent to Florida to advise as to the possibility of extending the cultivation of Cuban tobacco, and their reports were so favourable, that large areas were at once planted in Gadsden County, an example which was quickly followed in all parts of the State. It was not long before serious attempts were also made to produce the Sumatra wrapper leaf, and seeds were imported from the East. The methods of cultivation and curing adopted in Sumatra were carefully studied, and especially good results have been obtained by growing the plants under artificial shade. For the past twenty years Florida has been steadily regaining her reputation as a producer of first-class tobaccos, and at the present day cigars manufactured from Florida grown Cuban and Sumatran leaf are among the best obtainable.

In the early years of the tobacco trade the varieties in almost universal demand were the dark export types of Virginian tobaccos, and the light pipe types of Maryland leaf, and at the beginning of last century these were practically the only tobaccos cultivated by the American colonists. About 1820, however, a considerable demand arose for stronger coloured tobaccos, and to meet it artificial heat was employed in the curing processes. The present demand for light yellow tobacco first arose during the latter half of the century, probably the first crop of lemon-yellow leaf being raised in North Carolina in 1852. The well-known "Mahogany



A TOBACCO-CUTTING MACHINE



CUTTING CIGARETTE TOBACCO

manufacturing," "Burley," and "Perique" types of tobaccos have also been evolved during the last fifty or sixty years.

At the present day the principal tobacco-producing States of America are Kentucky (with a crop in 1905 worth sixteen million dollars), North Carolina (seven and a quarter millions), Virginia (six millions), Wisconsin (five and a quarter millions), Ohio (four and a quarter millions), Connecticut (four millions), Tennessee and Pennsylvania (two millions each), Massachusetts (one and a half millions), Maryland (one and one-tenth millions). New York, Indiana, Arkansas, Illinois, and some other States produce less than a million dollars' worth each.

The enormous extent of the industry in the United States may be judged from the following figures indicating the production of tobacco since 1800 :—

Year.	*Approximate Weight in cwts.*	*Year.*	*Approximate Weight in cwts.*
1800	955,000	1870	3,804,000
1810	1,050,000	1880	4,062,000
1820	1,130,000	1890	5,160,000
1830	1,270,000	1895	5,465,000
1840	1,960,000	1900	5,973,000
1850	2,230,000	1904	5,893,000
1860	2,706,000	1905	5,652,000

The figures given represent the quantities received at the factories, and it will be noticed that the returns for 1904 are less than the average returns for the United States given in the table representing the world's annual production of tobacco. The figures of the latter table are obtained from the planters and the discrepancy is due to the fact that after being sold to the dealers the leaf is subjected to a "fermentation" process, during which it loses from fifteen to twenty per cent. of its weight.

One of the most important factors affecting the successful production of good tobacco is climate, and it is only in the presence of sufficient warmth and moisture that the aromatic principles, upon which depend to so large an extent the quality of the tobacco, can be fully developed in the plant. There can be little doubt that the most famous tobaccos of the world, *e.g.* the Cuban, Turkish, and Persian varieties, owe their peculiarities largely to the climate in which they are grown, and the more closely the climate of a proposed new tobacco-growing district resembles that of some recognised tobacco country, the more likely will it be capable of growing a good leaf. Allowing climate, therefore, the premier position of importance in tobacco culture, we find that the character of the soil also affects to a great extent the quality of the product. The plant thrives best in a light sandy loam, rich in decaying vegetable matter or manures. As is so often the case, the importance of the manures depends not so much upon the amount of actual plant food rendered available by its decomposition, but upon the effect it has in keeping the soil in a well aerated, "loose" condition. So long as the soil is in a good physical condition its chemical composition is of secondary importance, for by

judicious manuring tobacco is often grown upon comparatively poor soils. The especial requirements of the tobacco plant with regard to soil constituents are potash and lime, and it is frequently necessary to supply these constituents to the field in the shape of manures. Ordinary stable manure is one of the best fertilisers where a large coarse leaf is required, but it has been found by repeated experiment that the best burning tobaccos are produced when the manure takes the form of carbonate of potash.

In the United States the field selected is ploughed in the autumn, a method which allows of the destruction of many of the larvæ of all kinds as well as producing a good tilth. In the spring the land is again ploughed, the manures added, and then two or three weeks before planting laid out in ridges about three feet apart. Meanwhile the tobacco seedlings have been raised in a special seed-bed or nursery which has been prepared with great care. The nursery plot is selected with a southern aspect if possible, and subjected to a process of "burning"—bushes, timber, etc., being laid upon the ground and ignited in such a way as to burn slowly in order that the earth may be thoroughly baked by the heat. The object of this process is chiefly to destroy the larvæ of insects hibernating in the soil. After the bed has been burned and had time to cool down, the baked earth is broken with a hoe until it is reduced to a fine porous condition. Manure is then applied, often in the form of guano, and, when this has been thoroughly incorporated, the bed is ready for sowing. Tobacco seed is extremely small, an ounce containing between 300,000 to 400,000 seeds, and there are two special difficulties which have to be met by the planter. In the first case, a large percentage of the seeds will not sprout, and hence it is necessary to sow a great deal more than is required. Secondly, the seed coat is excessively hard and resistent to the vivifying action of moisture, and it is not an uncommon practice to bruise the seeds by gently rubbing them with fine emery. The seed is mixed with fine ashes or earth, and then sown evenly over the surface of the bed, which is gently beaten down to retain the seed in the soil; it is most important, however, that the seed should not be buried too deeply in the soil or it will not sprout. When about four or six inches high the seedlings are transplanted in the field along the ridges at regular intervals of two or three feet. The operation is often carried out by hand, but transplanting with machines is now very generally practised in the northern cigar-tobacco States. The machine, which is drawn by two horses, makes the hole before planting, sets the plants, and firmly presses the earth round them. By its use a man and two boys can plant from two to six acres per day. During the growth of plants the soil is kept constantly broken with a horse cultivator or by hoeing, and great care is taken to keep down weeds. As soon as the flower buds begin to appear a most important operation must be commenced. The production of flowers and seed results in a deterioration of the quality of the leaf, and hence, unless the plants are being grown for seed, the buds are picked off by hand. At the same time certain of the leaves are removed from the plant, the number depending upon the judgment of the cultivator; the whole process is known as "topping." The young shoots or "suckers" in the axils of the leaves are also removed.



PACKING TURKISH TOBACCO

In due course the leaves begin to ripen, their colour changing to lighter shades of green and yellow, and yellow spots also appear; at this stage the leaves are richest in the nicotine, acids, and nitrogenous compounds which are necessary for a good tobacco. The leaves



do not all ripen at the same time, the lower ones ripening first, and it is owing to this fact that we have two methods of harvesting. The commoner method is to cut the whole plant down as soon as the middle leaves are sufficiently ripe, and after they have wilted, to cart them to the curing barn. For the production of the finer grades of cigar leaf, however, and also for much of the Bright Leaf tobacco, the leaves are picked or "primed" one by one as they become ripe. They are then placed in baskets and at once carted to the curing barn. When the "stalk-cutting" system is adopted, the stems are strung on to a "curing stick" about four feet long, which is thrust through the ends of the stems, or the stems are split in half from the top nearly to the bottom, and placed astride the sticks; and in this condition they are hauled to the curing barn. In the case of the primed leaves the latter are threaded on to a string when they arrive at the barn, and then tied to sticks upon which they hang during the curing process.

Within recent years a great deal of attention has been paid to the cultivation of the more valuable classes of tobacco under artificial shade. The method originated in Florida, where it was found that Sumatra tobacco, when grown under the shade of trees, produced a more satisfactory leaf. Artificial shading of the fields was then tried, posts being erected at regular intervals and arranged to support light wooden laths above. From Florida the idea extended to Connecticut, and now the practice is adopted in Cuba and Porto Rico. The shading is generally obtained by the substitution of a cotton cloth instead of wooden laths. The results are very striking; the yield of leaf is greatly increased largely owing to the regularity of temperature and humidity, and also to the fact that these two factors are maintained more or less constant during the night. The plants are also protected from the effects of the weather, and that the method is a success is proved by the enormous profits of the planters who have adopted it.

The tobacco plant is subject to the attacks of many insect and fungus pests, and space does not permit of more than a brief reference to the more important. The very young plants are attacked by "cutworms," which eat through the



A TURKISH PIPE-MAKER'S WORKSHOP



slender stalks. The leaves are devoured by "horn worms," which are so called on account of a prominent horn attached to the posterior end of the body, and other caterpillars (*Heliothis armiger*) destroy the terminal bud of the plant. The latter pest is an object worthy of particular notice, since it is the same which, under the name of the "cotton boll-worm," causes such terrible losses to cotton plants. These and many other insect pests cause considerable trouble to the tobacco grower, but he has a valuable remedy to hand in an essential compound known as Paris Green, which is sprayed or dusted over the plants affected and is fairly effective in destroying the parasites. There are also many fungal diseases, both of the living plant and also of the cured tobacco. One of the most important, which has caused enormous damage, is known as the "mosaic disease," since it causes the leaves to present a mosaic appearance as a result of irregular light and dark patches on the living leaves. This disease has been shown to be infectious, and is carried through the fields by the fingers of workmen who "top" the plants by nipping the buds (see above). The disease has been attributed to various causes. Some believe that it is the result of bacteria and poisonous ferments, whilst others incline to the belief that it arises from insufficient nutrition. This question, however, is far from being settled.

A BRIDAL PIPE FROM HOLLAND

THE CURING PROCESS

The curing process is one which must be very carefully carried out, for a good quality tobacco may be ruined by a lack of skill at this stage. The curing is not merely a drying process, but the exact chemical changes which take place are very imperfectly known. It appears tolerably certain, however, that the ferment or "enzym" which, during the subsequent "fermentation" of the leaf, give rise to chemical changes which develop the aroma of the finished tobacco, are formed during the curing process; and it follows therefore, that unless the curing is carried out with great care, the fermentation cannot be of a satisfactory character. In the case of certain tobaccos, such as the pale bright yellow varieties, aroma is not [illegible] as lightness of colour and in the preparation of these [illegible] curing is effected at such a high temperature as to destroy practically all the enzymes, so that there is but little fermentation in the subsequent process. On the other hand, it is most essential that cigar leaf should possess as fine an aroma as possible, and hence to allow of this being perfected during fermentation, the curing must be



SORTING TURKISH CIGARETTE TOBACCO

performed with great care to allow of the full development of the enzymes.

The harvested leaves, then, either on the stalks or picked separately and strung on strings, are brought to the curing barn, where they are placed on sticks, supported by cross-beams in the upper part of the barn. There are several methods of curing. The method employed for the production of the greater part of the tobacco for Europe is "fire cured." By this method the stalks are allowed to hang for four or five days until the leaves become a rich yellow colour, when small fires are lighted on the floor of the barn. The temperature is not allowed to rise above 90°, and then during about a week it is gradually increased to 150°, when the fires are allowed to burn out. The leaves are not yet dry, however, and the fires are again lighted and the process repeated until the drying is complete. The tobacco is then stripped from the stalk and the leaves, after being sorted into grades, are neatly tied into bundles or "hands," containing from six to twenty leaves. The hands are made into piles and covered with canvas.

"Flue curing" is adopted for producing the bright yellow tobacco, and great skill in regulating the temperature is necessary. In this method the fires are lighted outside the barn and the heat carried through the building by large air-pipes, so that the smoke and fumes do not come into contact with the leaves. In the first stage the temperature is maintained at about 90° ; the leaves turn a fine yellow colour, and enzymes are formed. Then the temperature is raised to 120 , which "fixes" the colour, and at the same time kills the enzymes, thus allowing of but little subsequent fermentation. The leaves are then finally dried at 135 , when they are graded and stored in bulk. From the nature of the curing it is obvious that this class of tobacco is incapable of undergoing a regular fermentation process as in the case of other tobaccos, since the enzymes are destroyed. It is practically ready for the manufacturers, as soon as it leaves the curing barn, though, like all tobaccos, it improves with age. "Air curing" is resorted to for cigar leaf and some varieties of smoking tobacco. The leaves are hung in well-ventilated barns for as long as six weeks, and the process depends upon the satisfactory regulation of the temperature by means of the numerous ventilators. "Sun curing," in the open air, is now seldom employed. The fermentation process is usually not carried out by the planter but by the leaf dealers. In a very commonly adopted method a quantity of leaf weighing from two to three hundred pounds is packed in a wooden case, and subjected to a considerable pressure by means of levers or screws. By this means the air is excluded from the leaf, but the moisture and juices resulting from the pressure escape through openings in the sides of the case.

Fermentation

The fermentation is allowed to go on at a constant temperature for several weeks, when the leaf is ready for shipment to the manufacturer. Within recent years the system known

as "bulk fermentation" is largely adopted. By this process enormous quantities of leaf are treated at one time, the amount varying from three to thirty thousand pounds according to the variety of tobacco required, the lighter sorts being fermented in smaller quantities. The fermentation is carried out in large rooms in which the temperature and degree of atmospheric moisture can be very carefully regulated. The leaves are piled regularly in huge "bulks," and, as soon as the temperature of the mass rises sufficiently, the bulk is pulled to pieces and re-built, with the outside leaves of the first bulk at the centre. This process is repeated two or three times, with the object of rendering the fermentation uniform. The causes of the changes which take place during the fermentation are by no means fully understood. For a long time there has been much dispute as to whether the changes are due to bacteria or to the development of special ferments in the leaf. The balance of opinion is in favour of the view that during the preliminary drying or curing certain ferments or enzymes are developed in the leaf, which have the power of causing the contents of the leaf cells to combine with the oxygen of the air. When fermentation is allowed to take place, these ferments become very active, and the cell contents, rapidly becoming oxidised, are decomposed into simpler substances which afford to the tobacco its valuable aromatic qualities. The nicotine of the leaf is quite unaffected, but the sugars and nitrates are destroyed, and the organic acids diminish in quantity.

The bacteria theory once had many supporters, and it was announced that not only had the bacteria been isolated, but that different types of tobacco acquired their characteristic aromas as a result of the activities of distinct species of bacteria; and it was even stated that it was only necessary to "inoculate" an inferior tobacco during fermentation with the special bacterium of a high-grade leaf to obtain all the aromatic qualities of the latter. Unfortunately —or the reverse—practical trials afforded no support to this contention.

When the fermentation is completed, and the whole process occupies three or four months, the leaves are very carefully graded and packed into bales, cases, or hogsheads for shipment to the manufacturer. The tobacco, however, is not fit for consumption until it has "aged." The period of ageing depends upon the class of tobacco, fermented leaf requiring a shorter period than ordinary unfermented tobacco for smoking, which requires from two to four years. The ageing softens and mellows the flavour, and is essentially a slow fermentation process.

The famous Perique tobacco is produced in one spot in Louisiana, viz., Grand Points, and, in spite of its world-wide reputation, the quantity grown is comparatively small. The greatest care is taken in the cultivation, and it is desirable that the ripening should take place under damp atmospheric conditions, which results in the formation in the leaves of large quantities of rich gummy juice.

The peculiar characters of the tobacco, however, are due no doubt to the peculiar methods of fermentation. The dried leaves are stripped from the stalk, made into small rolls, and then placed in a box and subjected to enormous pressure applied by means of levers. The pressure is removed every day and the leaves allowed to absorb the expressed juice



MAKING TURKISH RÉGIE CIGARETTES BY MACHINERY



MAKING CIGARETTES BY HAND

which has become oxidised. It is no doubt due to the pressure and absorption of these oxidised juices that we have developed the unique flavour and aroma of Perique tobacco.

Manufacture

The fully-aged tobacco reaches the hands of the manufacturer to be converted into the many varieties, brands and mixtures which are familiar to everyone. Most of the leaf reaching this country is "stripped," *i.e.*, deprived of the stalk and mid-rib, but if intended for the manufacture of "bird's eye," the mid-rib is retained, the "eyes" of the tobacco being merely thin slices of the stalk.

The manufacture of ordinary smoking mixtures is comparatively simple. The leaves are mixed according to the formulas of the firm, and afterwards damped. They are then transferred to the machine, where they are pressed into a light cake, which is finely cut up by what is essentially a chaff cutter. In the damping stage it is a common practice to flavour the leaf with various substances, sugar, liquorice, and certain aromatic substances being employed: further, chemicals, notably saltpetre, are also added to improve the burning qualities of the tobacco. The shredded tobacco is then dried or "roasted" on heated slabs or in special machinery, when it is ready for packing. "Roll" or "twist" is made by spinning the leaves by machinery in a manner very similar to that adopted in rope-making. The core of the twist is composed of broken leaf, but the covers are obtained from complete leaf. The material is fed into the machine which converts it into a cord of uniform thickness. "Cake" tobacco, as its name would indicate, is prepared by subjecting a "filling" between covering leaves to considerable pressure, the filling being packed into moulds.

Cigars are composed of two parts, a core formed of pieces of leaf placed longitudinally and known as "fillers," and a covering formed of perfect leaf called the "wrapper." The manufacture was formerly carried out almost entirely by hand, but now special machines are used in nearly all cases. Until within the last few years the wrapper was largely composed of Connecticut leaf, but its use was found to be wasteful. At the present time it may be said



TOBACCO

that for cigar manufacture what is required is a "filler" of Cuban tobaccos and a wrapper of Sumatra leaf. Cigarettes were originally entirely prepared by the smoker himself, but their consumption has assumed such gigantic proportions that all the vended brands are made by machinery, the structure of which essentially resembles that of the small hand-machines in common use. The machines cut the paper and gum its edge, measure out the right weight of tobacco, wrap it up in the paper which is automatically sealed, trim the ends of the cigarettes, and pack them in boxes!



MAKING CIGARS

Snuff is largely manufactured from the scraps and waste resulting from the preparation of mixtures and cigars. The fragments are chopped very fine, placed in heaps in warm, damp cellars, and then flavoured with certain substances such as liquorice, tonka beans, deer-tongue leaves, and various perfumes, the nature of which are trade secrets. The mass is allowed to ferment for several weeks, and then dried and finally ground to powder.

TOBACCO IN CUBA

In Cuba tobacco cultivation is second only in importance to the sugar industry, and no fewer than 80,000 people are regularly employed. In the early part of the eighteenth century the tobacco trade was a monopoly of the Spanish Crown, with a royal office and warehouse in Havana, and branches in Santiago, Trinidad, Bayamo, and Remedios, where the planters could store their tobacco, receiving such prices as might be established by the Crown for each particular crop. Later, the monopoly was sold to private individuals, but in 1760 it was again taken over by the Crown, and it was not until 1817 that the trade and cultivation of tobacco were declared free on payment of a tax by each planter, equivalent to one-twentieth of the production. Since that date the taxes have varied according to circumstances, but usually they have been very high. There is no reliable information as to the amount of tobacco produced in Cuba in the early days, owing to the enormous smuggling which went on. From such data as are available, however, it appears that during the eighteenth century the annual export was probably not less than 20,000,000 lb., and it is certain that during the periods of Crown monopoly the amount was less than during the period of private monopoly; when the monopoly was completely abolished, the production immediately increased. Coming to more recent times, it appears that the approximate production in 1894-5 was over 62,000,000 lb. of leaf, or 560,000 bales valued at more than £4,000,000. In 1904 the production was 416,000 bales.

More than half of the total amount raised is exported in the leaf, and the remainder, about forty per cent., is used in the manufacture of cigars and cigarettes. Nearly one-half of the export is to the United States.

Tobacco is raised as an article of commerce in but four of the six provinces of Cuba, though there is no reason why the crop should not be raised in the other two. To the trade the tobacco of Pinar del Rio is known as "Vuelta Abajo," that of Havana as "Partido" and "Semi Vuelta," that of Santa Clara as "Las Villas" or "Remedios" leaf, while the leaf of Santiago is known as "Oriente."



SORTING CIGARS

The quality of Cuban tobacco is world-renowned, more especially that known as the Vuelta Abajo, which is used in the manufacture of some of the finest cigars in the market. Innumerable attempts have been made in other districts of Cuba and in other countries to produce this variety, but all have signally failed, and the secret of its superiority remains unsolved. The Sierra de los Organos, a range of mountains running along the entire length of the province of Pinar del Rio, is no doubt a potent factor, since it breaks the high winds which do so much damage to the plants elsewhere. Various other causes have been suggested, and probably they all contribute to the combinations which produce this excellent tobacco. To what its superiority is especially due will probably be known when the soils on which it has been cultivated for so long have been carefully analysed and compared, and when the chemical changes of the curing and fermentation processes are better understood.

TOBACCO IN SUMATRA

As has been mentioned above, Sumatra tobacco is especially valued by manufacturers as a wrapper for cigars on account of the fine quality and extreme thinness of the leaf. It is stated that there are no fewer than two hundred leaves to the pound, and one pound is sufficient for the wrappers of five hundred cigars. Apart from the thinness of the leaf, much of the value of the Sumatra tobacco is dependent upon the peculiar qualities of the soil, and more especially upon the infinite care that is taken throughout the whole period of its production. A brief account of the industry will therefore not be without interest.

Up to 1862 a tobacco of very good quality had been produced in the neighbouring island of Java, and the cultivation had been one of considerable commercial success. About this time, however, prices fell, and the planters began to make enquiries as to suitable country for raising a grade of tobacco equal in quality to the superior varieties which were driving them from the market. Following the advice of an Arab trader, a Dutch planter visited Deli in the east coast of Sumatra, and was so impressed with the local conditions that in 1864 a Rotterdam company started a plantation in the neighbourhood and obtained a crop of some fifty bales. The superior quality of the tobacco attracted the attention of experts to such an extent that five years later a powerful Dutch syndicate decided to raise tobacco in Sumatra on a large scale. Many companies and private individuals soon followed this lead, and in the tobacco district at the present day there are nearly forty registered companies and as many private planters. The magnitude of the industry may be gauged from the fact that some companies employ as many as 16,000 coolies, with a staff of white experts numbering upwards of two hundred. The fact that the dividends have been known to reach seventy-five per cent. is sufficient proof of the commercial success of the undertakings.

The tobacco district of Sumatra borders on the Straits of Malacca, and extends as a belt forty miles wide and five or ten miles back from the coast. The climate is naturally a tropical

one, and the soils are mostly volcanic in origin, the finest tobaccos being raised on those resembling clay or silt in texture. The land is not purchased freehold by the planters, as is so often the case in tropical agriculture, but is leased from the Sultan for a period of seventy-five years under the sanction of the Dutch Government. By far the greater part of the labour is performed by Chinese coolies imported directly from China, and there can be little doubt that but for the yellow labour the successful cultivation of tobacco in Sumatra would be impossible. The Chinese are most industrious workers, and stand the exacting climate well; they very quickly learn their new duties, for it is stated that the imported coolie has to be taught from the beginning, since he has no previous knowledge of tobacco cultivation.

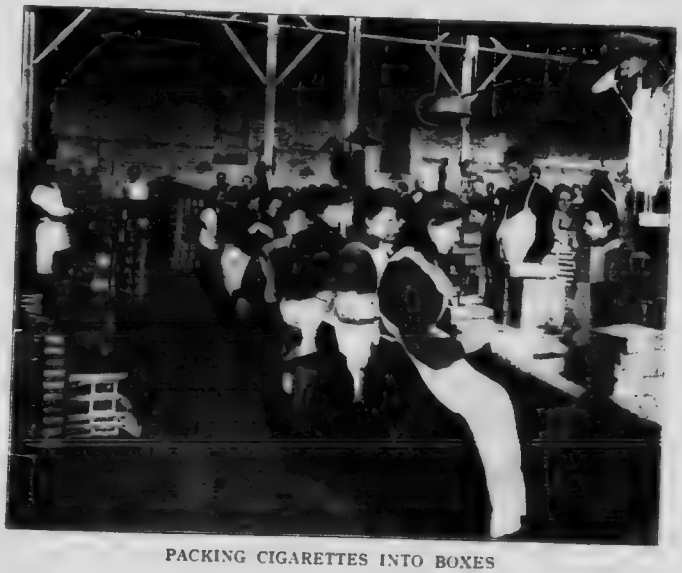
TOBACCO IN THE PHILIPPINES

The soil and climate of the Philippines are peculiarly well suited to the cultivation of tobacco, and next to the finest qualities of the Cuban and Turkish tobaccos, the product of these islands is considered the finest in the world. The famous Manila cheroots enjoy a universal reputation for good quality. The product of the Cayagan province is perhaps the finest, and the high quality of the tobacco is usually ascribed to the peculiarities of the soil, which consists of alluvial deposits annually brought down by the rivers. Under the somewhat severe terms of the late Spanish monopoly, the industry showed signs of deterioration, but it is probable that with the removal of these restrictions a revival may take place.

TOBACCO IN THE BRITISH EMPIRE

India and Ceylon

Tobacco is said to have first been introduced into India by the Portuguese in the early years of the seventeenth century. Since that time several attempts have been made to extend and improve the tobacco industry of British India, and at the present day certain Indian tobaccos and cigars have an established reputation in England. In 1829 samples of Maryland and Virginia seed were sent to India by the direction of the East India Company, and the quality of the leaf produced was regarded as equal to some of the best West Indian varieties. Much of the tobacco, however, was of comparatively inferior quality, and although acceptable to the natives, was quite unsuited to Western tastes. Nevertheless, the experiments had shown that an article of good quality could be produced in India provided the best sorts of seed were used and proper methods of cultivation and preparation adopted. The Government therefore, in 1876, established an experimental farm of eight hundred acres at Ghazipur, on the Ganges, and employed a Virginia planter to superintend the curing of the leaf. Ghazipur tobacco is now recognised as one of the best raised in India.



PACKING CIGARETTES INTO BOXES

Tobacco for local consumption is raised in small patches in most parts of India, but from a commercial point of view the chief



By Permission of Messrs. Gallaher

SPINNING ROOM—GALLAHER'S FACTORY

districts concerned are Bombay, Madras, and the Punjab. The plantations and factories are often managed by American experts, and most varieties of the plant, including the Persian "Shiraz" tobacco, have been experimented with. In Madras some of the most celebrated of its tobaccos are grown in the Northern Circars, and in the deltas of the Krishna and Godavery rivers. The famous Dindigul brand is raised in plantations which are managed upon the most modern lines, and the cheroots of Trichinopoly are well known.

The total area under cultivation in India in 1905 was upwards of 1,000,000 acres, and the value of the export for the same year was £138,700.

Considerable quantities of tobacco are also grown in Ceylon, where it is used for local consumption by the natives and for export to India. The quality of the tobacco would be quite unsuitable for the Western market.

British North Borneo

In other parts of the British Empire the cultivation of tobacco has met with varying measures of success. The industry is of considerable importance in British North Borneo, where in 1883 the first tobacco-planting company, under the name of the Chinese Sabah Company, started a tobacco plantation at Sandakan Bay. Tobacco had long been known to exist in Borneo, but it was the remarkable success of the plantations in the neighbouring islands of Sumatra and Java which first drew attention to the possibilities of Borneo as a tobacco-producing country. Samples of the product were sent to the Indian and Colonial Exhibition of 1886, and very favourable opinions were expressed by the brokers, who, however, pointed out the necessity for adopting improved methods in the drying and fermenting processes. In later years great advances were made in producing an article of good quality, and Borneo cigars and tobacco soon became well known in England. The leaf grown is chiefly intended as wrappers for cigars. Planting is carried out in April and May, and in seventy days the leaves are gathered, so that only three months elapse from the time the seeds are put in the nursery-bed until the gathering of the crop.

At the present day there are three large tobacco companies in British North Borneo, the survivors of a much larger number which existed a few years ago. Much competition has been experienced at the hands of the Sumatra planters with their famous leaf, and although tobacco is one of the most important planting industries of the country, it at present shows no signs of immediate expansion.

Jamaica

In Jamaica the cultivation of tobacco has lately received much attention. The soil, climate, and general conditions are very favourable in many parts of the island, and the area

at present under tobacco is about four hundred acres. The tobacco trade has progressed very satisfactorily during the past eleven years. Jamaica cigars and cigarettes, which are manufactured at Kingston, have gained a very enviable reputation in the market, and the industry may now be considered to be well established. In the opinion of many experts, Jamaica cigars are the finest produced in the British Empire. The exports in 1904-5 were valued at £22,408, as compared with a value of £19,567 in the preceding year, and these figures are exclusive of the locally grown tobacco consumed in the island.

Africa

Several of the British African colonies have long grown tobacco, and some of the newer countries are making serious attempts to produce a marketable article; but up to the present comparatively little has been done except in British Central Africa, the tobacco of which has a good reputation.

The British South Africa Company is paying special attention to tobacco in Rhodesia, and has called in the aid of the highest expert advice in relation to its cultivation and preparation. The different varieties of soil found in the country are capable of growing light cigarette tobacco, cigar leaf and heavy smoking tobacco, all of excellent quality. Cigarettes made from Rhodesian-grown Turkish tobacco have been on sale in London for the past two years, and of their high quality there can be little difference of opinion.

The possibilities of successful tobacco culture in the Transvaal and the Orange River Colony are considerable, and the Government has been sufficiently alive to this fact to engage the services of one of the most prominent tobacco experts in order that the farmers may become acquainted with the best methods of cultivation and preparation.

Australasia

Several attempts have been made in Australia to establish a tobacco industry, but the net result is comparatively small. In Queensland the crop is grown in the south, but the area planted is not much more than five hundred acres. The tobacco acreage in New South Wales is also small in spite of the fact that in many parts of the State the climate and soil are well suited to the plant. In Victoria there is a small area under tobacco, but at one time the crop was much more extensively grown. New Zealand has also attempted tobacco-growing, but the cultivation is now abandoned.



By permission of Messrs. Gallaher

CORNER OF LEAF ROOM—GALLAHER'S FACTORY

The United Kingdom

In order to protect the growing industry in Virginia, an Act was passed in the reign of Charles II forbidding the cultivation of tobacco in England; and since that time the cultivation has been prohibited under heavy penalties, chiefly for fiscal reasons. From time to time, however, the Government has permitted experimental

cultivation. In 1822 the restrictions in the case of Ireland were removed, and at the present day tobacco cultivation is allowed in the sister isle. In 1886 experiments were conducted in England under certain restrictions, and several agriculturists in Norfolk, Kent, and other counties grew the plant with such success as to definitely establish the possibility of growing tobacco in England as a commercial crop. Permission to continue the experiment, however, was withdrawn, and a letter published to the *Times* of October 8th, 1906, from the Board of Agriculture and Fisheries, shows that there is practically no chance of the cultivation being again permitted.

TOBACCO FACTORIES

The enormous strides which have characterised the preparation and the manufacture of the various commercial products during the past quarter of a century have been as marked in the tobacco industry as in any other. As is well known, the cacao or cocoa trade is most closely associated with names which have a world-wide renown, and the same thing is becoming true of the tobacco trade.

It is impossible to enter into full details as to the different firms which have become identified with the trade, or to give any complete account of the methods of manufacture adopted by them. There are, however, two illustrations inserted in the text which show two of the rooms of the great factory of Messrs. Gallaher, Limited, at their headquarters in Belfast. This factory is one of the largest in the world devoted to the tobacco industry. It consists of five storeys, and is over 80 feet in height. The floor space alone covers something like 12 acres. The work is carried out on the most approved and up-to-date principles, and a visitor cannot fail to be struck by the intricate and ingenious devices in all the departments which illustrate the various stages of preparation and manufacture. The bonded warehouse which is owned by Messrs. Gallaher is a mammoth building, six storeys high, divided into 30 vast apartments, and capable of storing 20,000 hogsheads of tobacco leaf. The export factory, which adjoins the main factory in Belfast, is perfectly equipped, and the machinery is capable of producing every class of tobacco which can be demanded by the trade in any quarter of the world.

It is interesting to note that the whole of this vast business has been built up by one individual, Mr. Thomas Gallaher, and his enterprise and energy have earned for him the title of the "Tobacco King."

THE GRAPE-VINE

THE history of the grape may be traced back to very ancient times, to ages, indeed, of which we have no written record. Seeds of the plant have been found in the Lake-dwellings of Castione, near Parma, which date from the Bronze Age, in the pre-historic settlement of Lake Varese, and in the Lake-dwellings of Wangen, in Switzerland. Of the cultivation of the vine at these remote periods we have no certain knowledge, but it is probable that in Egypt the grape was cultivated and wine made nearly six thousand years ago. The Bible affords evidence of the early use of wine among the Semitic peoples, and its use among the Phœnicians, Greeks, and Romans is well known.



AN AUSTRALIAN VINEYARD



AN AMERICAN VINE GROWING IN SICILY

The vine (*Vitis vinifera*) belongs to the natural order *Vitaceae*, a family which includes the Virginia creeper, and grows wild in the temperate regions of western Asia, southern Europe, Algeria, and Morocco. Whether these countries are the true home of the plant is a point which is open to discussion, but the majority of botanists are of opinion that the vine may be regarded as truly indigenous to the Trans-Caucasian provinces of Russia, whence the seeds have been widely disseminated by birds and by the agency of man.

Knowledge of the principles of viticulture and the manufacture of wine spread but slowly from the home of the industry in western Asia, a fact which is to be explained largely as a result of the inefficient methods of transport existing at the time which prevented wine being carried any great distance without deterioration. Greece and Italy were the first countries to copy the methods of the Eastern wine-growers, and, under the Greeks, viticulture made great strides, the wines of Candia and Smyrna being largely exported to the Romans. Gradually the cultivation of the grape spread over the whole of central Europe from the Mediterranean to the plains of Germany, from Spain to Great Britain, and from thence the cultivation was carried during the Middle Ages to the fertile lands of the New World.

At the present day the finest vineyards are still to be found in Europe, and the wines of France, Italy, Germany, Spain, and Portugal are admittedly unsurpassed by any in the world.

Each country, and indeed each district, has its characteristic wine, and the products of the above countries are as distinct from each other as they are from those of Greece, Turkey, Roumania, and Switzerland. In the New World extensive vineyards are to be found in Chili, Peru, Bolivia, Uruguay, and other parts of South America, and in the United States great

wine-growing districts exist in Florida, Virginia, and California. In spite, however, of the extent of the cultivation in the New World, the wines do not equal those of Europe, which stand unrivalled. The wine-making countries of Africa are limited to Algeria and Tunis, where the industry is one of considerable importance, and to Cape Colony, whose wines are now in part regaining something of their former popularity. In the southern hemisphere viticulture has made great strides in several of the Australian states, and the wines of these countries have an established reputation in the world's markets.

THE VINE

Having thus briefly outlined the history and present condition of the vine-growing industry, we will turn our attention to a consideration of the plant itself, and to the methods of cultivation and manufacture which have for their object the production of the wines of our tables.

The majority of people in this country would describe the vine as a climbing plant, with large, deeply lobed leaves, and bearing bunches of round berries, either green or blue-black in colour. While this description would hold good for a common variety of the vine, it would be quite inaccurate for many others, for the vine is a very variable plant, and there are innumerable varieties cultivated in different parts of the world. While some vines are climbers, others may be trained as hedge plants, others may be induced to form arbours, but the most variable characters of the plant are to be found in its leaves. These are frequently deeply lobed, of a brilliant green colour, and with well-marked veins and downy coating on their under surfaces. The greatest variation from this type, however, is found in the different varieties of the plant. The fruits grow in clusters which may be long and pyramidal, or short and dense, and much variation is found in the characters of the berries or grapes themselves. Some are as large as a plum, as in the American varieties, others are not much larger than a pea, while the differences in colour are known to everyone. In some cases the pulp is soft, in others firm, and the juice may be either colourless or red. The well-known "bloom" of the common hot-house grape is absent in many varieties.



PUMPING WATER FOR IRRIGATION IN PORTUGAL

The vine will yield satisfactory vintages only when grown in a temperate climate, and supplied with a moderate amount of moisture. Too much water results in an excessive growth of the leaves and shoots, and the grapes are watery and acid; on the other hand, in a dry climate the fruits are small and contain too large a proportion of sugar to render them of use for wine-making. Light is another important factor, and the cultivator chooses situations for his vineyards where the plants will not run the risk of scorching by the sun, nor, on the other hand, be deprived of a generous supply of its warmth and light.

Although the climatic conditions must be very favourable for the grape-vine, the plant is much less exacting with regard to soils, for it will accommodate itself to most, growing especially well in those of a gravelly, chalky, or stony nature. Nevertheless, a knowledge of the chemical composition and physical condition of the soil is of the utmost importance in viticulture, since the flavour of the wine depends to a very large extent upon these factors, for under identical atmospheric and climatic conditions we may have wines produced of totally



GATHERING THE FRUIT IN PORTUGAL



GATHERING THE GRAPES

different character, the difference resulting entirely from the variations in the chemical and physical constitution of the soil. Locality, again, has a marked influence on the quality of the wine produced. Vineyards such as those of America, Australia, Algeria, and Tunis, which are chiefly planted in the rich soils of plains, and but indifferently protected from excessive rain and sun, produce large quantities of fruit, but of a comparatively poor quality.

On the other hand, the fruit from the vineyards of hilly and mountainous districts, where the soil may be considerably poorer, as a general rule yields a wine of a much more delicate flavour. The vineyards of valleys, again, have their own special disadvantages, for here the vines may be exposed to excessive moisture and insufficient sunlight, and hence rendered more susceptible to disease. In spite of all these difficulties, however, the experience of centuries and the resources of modern science render it possible in many instances for the viticulturist so to modify and ameliorate natural conditions that a good wine is often produced from vineyards which are situated under any but ideal circumstances.

Planting a Vineyard

The first step in planting a new vineyard is to thoroughly prepare the soil by ploughing or digging, the laborious process of digging being resorted to only when ploughing is impossible owing to the situation of the field. At this stage the soil is often mixed with another of proved quality from a different locality to make up any suspected deficiency, and then the whole field is thoroughly dressed with a slowly decaying manure, such as the refuse of leather or horn.

The vines to be planted out are raised either from slips, layers, or seeds. In the former case, which is by far the most common method, a branch which has lost its green colour and has become covered with a thin brown bark, is cut into lengths of about sixteen inches, which are tied up in bundles, and wrapped round with damp moss. They are then planted in the fields directly, or may be placed for a time in a special nursery. "Layering" is another method frequently resorted to. In this case a branch still attached to the mother plant is bent down to the ground and covered with soil to a depth of about eight to twelve inches, in which it strikes root. After about two years such a "layer" or "sucker" is sufficiently strong to be separated from the parent plant, and the new vine is then treated in exactly the same way as a slip or cutting. The third method, viz., raising from seed, is almost entirely restricted to testing new varieties produced by artificial cross-fertilisation. This interesting and delicate operation, which is carried out by experts, consists in the transference of the pollen of one variety of vine of known value to the stigma of another, which also possesses approved qualities, the object being to produce seed which will give rise to plants combining the characters of the two parents. Improved varieties are also produced by the ordinary process of grafting.

The method of planting varies considerably with the customs of the people and the extent and shape of the vineyard. Commonly the slips are placed in holes made to a depth of from

twelve to sixteen inches with a wooden or iron planting-stick. The labourer places his foot on the cross-bar of the planting-stick, pressing the latter into the ground to the required depth, and then plants the cutting in the hole, which is filled up with fine earth and easily assimilated manure. In other vineyards the spade is employed for making the hole, the advantage of this method being that the larger hole allows of more fine earth and manure being placed in the immediate vicinity of the young plant, which forms under these circumstances a much more satisfactory root-system. A third method of trenching is also commonly practised, in which the plants are placed at regular intervals in trenches previously prepared, which are subsequently filled in with the earth from the trench immediately in front. The distances between the vines is in all cases determined by several factors, the chief of which are the fertility of the soil, the known requirements of the variety planted, and last, but not least, the nature of the implements to be utilised in the subsequent cultivation of the vineyard; for it is obviously important that if water-carts and ploughs are to be used in the vineyard while the crop is coming to maturity, sufficient room must be left between the rows to allow of such cultivation. Various methods of training the vines are employed in different countries. In north and central France the vines are supported by a strong stake of chestnut, and such a method is commonly adopted in Germany and other countries.

Perhaps the most important part of the cultivation of the vineyard after the plants are well established consists in scientific pruning and efficient weeding. The pruning is performed by highly trained vine-dressers, who use specially designed scissors for trimming the shoots; the system of pruning depends to a great extent upon local custom. Weeding generally is effected by ploughing or sometimes by hoeing, but it is essential that such ploughing should not take place while the vine is in bloom, or the unavoidable shocks given to the plants result in the fruit not being set. In small vineyards the weeding is done by hand, and although the process is long and very fatiguing, since the labourer must use a short hoe, there is little doubt that the plants run less risk of injury than when the plough is used.

The Enemies of the Grape-Vine

During its growth the grape-vine is exposed to the risk of attack from several destructive enemies belonging to both the vegetable and animal kingdoms. Some of the pests are so rapid in their onslaught that when once they have obtained a hold on the plant it is quite impossible to check their progress even if the most energetic remedies be resorted to; on the other hand, many diseases may be checked and even avoided altogether by the timely and vigorous adoption of certain well-known remedial measures.

Snails, moths, plant lice, leaf rollers, and numerous other insects do great damage in the vineyard, and many are the methods which have been adopted by the cultivator to combat their ravages, often with a considerable amount of success. But great as is the damage done by the above pests, their effects pale before the ravages caused by the dreaded



THE GRAPE HARVEST



FRUITFUL VINES

phylloxera, which has caused, at one time or another, enormous losses in the vineyards of most of the wine-growing countries of the world. *Phylloxera vastatrix* is an insect belonging to the plant lice family or *Aphidae*, a group well known for their destructive habits. It is a native of North America, and in Europe first made its appearance in France, appearing later in Italy, Spain, Austria, Germany, and finally in Hungary. Subsequently it caused enormous damage in the vineyards of the East, and when the pest again reached the Mediterranean many of the plantations of Algeria were utterly ruined. The Cape of Good Hope was next attacked, and, after nearly ruining the wine industry of the colony, outbreaks occurred in both North and South America. The disease has also appeared in Australia, and practically the only vine-growing country which has hitherto escaped the scourge is Tunis, where stringent measures have systematically been taken to prevent the introduction of the insect. Vines attacked by the phylloxera present a very typical appearance. The plants develop comparatively few leaves, which are small and quickly lose their colour, becoming yellow or yellowish-brown; another striking feature is that the edges of the leaves become rolled back. At a later stage the effects of the disease are noticeable in the grapes themselves, which become arrested in their growth and much wrinkled.

If the roots of such a plant are exposed and carefully examined with a lens, the cause of the disease becomes evident. The rootlets are seen to bear numerous firm, yellowish

tubercles, which later become dark and rotten, and on the tubers may be found large numbers of the phylloxera itself—minute yellowish-brown creatures, provided with six legs and a strong tubular proboscis, by means of which they pierce the bark of the root and rob the plant of its sap. These insects are wingless females, which from March to October lay enormous numbers of eggs which give rise to females exactly similar to themselves. During the summer, however, a second form of insect appears among the root-dwellers, although the eggs from which they are hatched possess no characteristics to distinguish them from the others. The new insect, when mature, is provided with wings, and, after emerging into the air through the soil, flies about the vineyard during the summer and early autumn, feeding upon the juices of the leaves and twigs of the vines. The winged insects or nymphs, which are all females, lay their eggs on the leaves, and in the next generation we have the appearance of insects of both sexes, male and female, neither of which possess wings. The life of these forms is very short, and is taken up with producing a new generation of females, also wingless, which are known as the stock-mothers. These latter attack the tissue of the leaves, forming galls on the under surface, where they take up their abode. We at last complete the complicated life history of this pest, for the numerous progeny of the stock-mothers emerge from the galls, and, descending to the roots, become the root-dwelling forms which once more start the vicious cycle.



PHYLLOXERA. THE WINGED INSECT



PHYLLOXERA. WINGLESS FEMALE AND EGG



EGGS OF PHYLLOXERA

Although the attacks of phylloxera frequently result in the ruin of the vineyard affected, the vigneron is not entirely without remedy. America is the home of the pest, and it seems but just of Nature to provide from the same country the salvation of the afflicted vine-grower. Many of the native vines of America have become immune, as it were, from the attacks of the insect after long ages of susceptibility, and the remedy which has met with the greatest amount of success consists in rooting up and destroying all diseased plants, and planting stocks of the American "phylloxera-resisting" varieties. When once established, cuttings of the local vines are grafted on to the stocks, so that we have what may be regarded as a composite plant—a plant whose roots are proof against the attacks of the insect, and whose fruit produces a wine which still maintains the local tradition.

Diseases due to the attacks of fungi have also caused enormous losses to vine growers. The most important is undoubtedly that caused by *Oidium* (*Erysiphe*) *Tuckeri*. The disease was first noticed in England near Margate in 1845, and in less than seven years it had spread through all the wine-producing countries of Europe. The fungus appears on the surface of

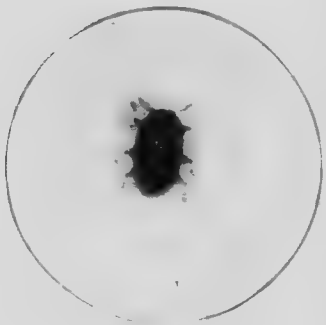
the young vine leaves as a delicate white weft of filaments which send suckers into the leaf cells, absorbing nutriment from them. It rapidly spreads over the surface of the plants and finally attacks the grapes themselves, causing them to become spotted and at last completely withered. The fungus is propagated by means of spores which are found in chains on delicate filaments which project from the surface of the plant. In 1892 another means of reproduction was discovered in Europe, but that already described is by far the most important. The most effective means of checking and even preventing this disease has been found to consist in puffing flowers of sulphur on to the plants before the dew has evaporated.



PHYLLOXERA. THE WINGLESS FEMALE



PHYLLOXERA. THE WINGLESS MALE



PHYLLOXERA. WINGLESS FORM JUST HATCHED

"Black rot," caused by the attacks of another fungus, *Laestadia* (*Physalospora*) *Bidwillii*, affects all young organs and shoots of the vine. The grapes first show signs of the disease when about the size of peas, and later they fall off, either singly or in clusters. Black rot is one of the most dreaded of the vine diseases in America, and although it has been observed in France, the fungus has as yet done comparatively little damage in Europe. Spraying the vine with the solution of copper sulphate (blue vitriol) and lime known as "Bordeaux mixture" is generally recommended as the most effective remedy.

"Anthracnose" of the vine, known on the Continent as "brenner," "pech," and "charbon," has also caused great losses. The fungus, *Phoma* (*Sphaceloma*) *ampelinum*, penetrates the leaves, bark and grapes, and kills the tissues. On the leaves and grapes sunken dark spots occur, and later the spots, when dried up, drop out of the leaves. Spraying with solutions of copper sulphate appears to be the best remedy.

Among other fungi attacking the vine may be mentioned *Peronospora cubicola*, a pest closely allied to that causing the disastrous potato disease; and *Dematophora necatrix*, which causes a very destructive root disease often confused with that resulting from phylloxera.

The Harvest

When the grapes are ripe the gathering begins, but in some of the hotter districts the grapes are gathered before reaching full ripeness in order that the tartness may preserve the wine. For some liqueurs, on the other hand, it is necessary to have a large amount of sugar and alcohol in the fruit, and hence for these wines the grapes are gathered when somewhat overripe. As soon as the grapes have been picked they are transferred to cellars to await the first processes in the manufacture of wine. Before dealing with this subject, however, it would be well to mention that no small proportion of vine-growers devote considerable attention to the cultivation of grapes suitable for the table. Spain furnishes supplies of excellent dessert fruit, and the hot-house grapes of England, Belgium, and the Low Countries are world-famous, especially those of England. One of the finest varieties of table grapes is the Chasselas of Fontainebleau, which owes its name to the celebrated vine in the Royal Park at Fontainebleau. The

fruit is borne in large clusters which, however, contain relatively few golden-green berries, characterised by a very thin skin and a sweet pulp of exquisite flavour. Another variety of grape, known to everyone under the name of "currants," is extensively grown in Greece, and is the object of an enormous trade, the principal centres of the industry being at Patras in Morea and the isle of Tante.

Besides yielding a first-class dessert fruit, grapes are the source of the valuable raisin and muscatel. Raisins are nothing more than dried grapes, and it might naturally be supposed that wherever the vine is cultivated for wine-making these raisins would be produced. This, however, is not so, for the production of the dried fruit is confined to certain well-marked vine-growing districts, the most important being the country in the neighbourhood of Malaga and Valencia in Spain, whence we respectively receive the muscatel and the well-known pudding raisin. Certain districts of Asia Minor produce large quantities of the stoneless sultana raisin, and smaller quantities are exported from Greece. Within recent years a large trade in raisins and muscatels has developed in California, and the decay of the wine industry in South Africa has resulted in the vine-growers turning their attention to raisin production. Further, the Australian states are taking their part in the supply of this popular fruit, and at the present time the export of raisins, especially from South Australia, is considerable. Lastly, great quantities of raisins are produced in many districts of Persia, but they are principally consumed locally, largely owing to insufficient means of transport.



ROOT-SYSTEM ATTACKED BY PHYLLOXERA

The method of drying the grapes varies in different countries. In Spain the finest varieties of raisins are produced by partially cutting through the stalks of the bunches which are allowed to hang on the vines, and the drying and curing of the grapes is hastened by a vigorous thinning

of the leaves to allow of the penetration of the sun. Generally, however, the ripe bunches are cut from the vine, and then placed in the sun on sloping floors until the fruit is sufficiently cured. In Asia Minor the drying is retarded by sprinkling the bunches with oil, thereby reducing evaporation, and this process is said to preserve the fruit in transit. When dry the fruit is carefully graded, and either packed in fancy boxes, as in the case of muscatels, or else exported in bulk. The pick of the market comes to London. (See article on "Fruits.")

WINE-MAKING

The primary purpose of viticulture, however, is the manufacture of wine. Briefly put, the process consists in allowing the juice of the grapes to ferment under certain conditions, when it undergoes fundamental changes, and is converted into wine, the varieties of which are as numerous as the methods employed in producing them. In the preparation of red wine the grapes are taken into cellars, the temperature of which can be carefully regulated. In former days the next stage was to place the vintage into an enormous bowl and allow the grapes to be pressed by men dancing on them. The obvious objection to such a process has led to the employment of machinery, and in all large wine factories at the present time the grapes are passed between horizontal cylinders which press out the juice without crushing the stones. The expressed juice, or "must," as it is called, is collected in bowls and allowed to ferment, a process which consists essentially of the conversion of the sugar of the grape into alcohol and carbonic acid gas, the change being brought about by a unicellular organism closely allied to the yeast plant. The fermentation is most vigorous at a temperature of about 20° C., and the more favourable the conditions of temperature and the larger the quantity of must, the quicker the process is completed; depending upon these conditions it may be from twenty-four hours to eight days before the process is completed. At the height of the fermentation the liquor is in a condition of considerable commotion, and if the stalks of the bunches have been left in the bowls the whole mass rises to the surface. Sooner or later, however, the turbulence subsides, the stalks sink to the bottom, and the liquor becomes coloured and acquires an alcoholic flavour; when the fermentation has completely ceased the first wine or "vin de goutte" is drawn off. The colour and flavour of the wine depends upon the length of time the must is allowed to remain in the bowls, but as soon as the required condition is reached the wine is transferred to barrels, the lees being kept back by means of a sieve. The lees are not discarded, however, for out of them, by successive pressings, wines of inferior quality are made. These wines are of sharp flavour, and are generally casked separately from the "vin de goutte."



OIDIUM ATTACKING THE GRAPES

There are numerous varieties of red wine, and they are made in all vine-growing countries. The French red wines especially are highly valued, and of their excellence there can be but one opinion. Among the red wines of Burgundy may be cited those of Musigny, Richebourg, Romanée, Chambertin, Corton, Beaune des Hospices, Pommard, Volnay, Allos du Roy, and Clos de Vougeot. The Clos de Vougeot is one of the most highly prized of the products of

the beautiful Burgundian vineyards; its origin can be traced back to A.D. 1110, when the monks of Cîteaux received the vineyards from Hugues le Blanc, lord of Vergy, and cultivating it with infinite care, succeeded in producing a wine which has maintained its reputation for centuries. The wines of Beaujolais such as Macon, Thomas, Fleurie, and Moulin-à-vent are also well known, and the pride of the banks of the Rhone are l'Hermitage, Côte-Rôtie, and Chateauneuf-du-Pape. But the French wines, however, which enjoy perhaps the greatest popularity in the land which produces them are the world-famous red wines of Bordeaux, some of the principal varieties of which are Haut Brion, Château-Margaux, Château-Léoville, Château-Lafite, Château-Lagrange, Château-Larose, Château-Millet, Mouton-Rothschild, Château-Latour, Branaire, Montrose-Dolfus, Ducru-Beaucailloux, Clos d'Issan, St. Estephe, St. Emilion, and Médoc. Although the wines of Bordeaux have been famous for centuries, it was not until towards the end of the eighteenth century that they became really fashionable, a state of affairs which was largely brought about by the influence of Marshal de Richelieu, who introduced them to the notice of the Parisians.



VINE ATTACKED BY OIDIUM

Having thus briefly dealt with red wines and their manufacture, we will turn our attention to the white varieties. White wines are made in a manner quite distinct from that adopted for red wines, but it is a common error to suppose that white wines are made solely from white grapes to the exclusion of purple fruit. It is quite true that many grapes are quite unsuitable for white wines, since their juice is too strongly coloured, but the total exclusion of these varieties for white wines is by no means the case.

The wines are produced by two distinct methods. In the one case the vintage is thrown into huge bowls or basins and the juice, as soon as it has been pressed out, drawn off and placed into casks, where it is allowed to ferment; it is very important that the sediment should be abstracted as soon as possible. In the other method the grapes are taken directly to the press and great care is exercised to avoid too great pressure, which would result in the must becoming coloured by the expressed juices of the stalks. In both cases the lees are placed on hurdles and the wine which drips from them is collected and added to that obtained first. It frequently happens that in spite of all precautions to the contrary the must is of too strong a tint, and to effect the decolourisation of the wine it is the practice to treat the must with sulphuric acid or charcoal.

Owing to the early extraction of the lees the fermentation of white wines is much slower and less vigorous than in the case of red wines, and to facilitate the process the wines are often transferred to other vessels. The liquor in these vessels is kept at a constant level by the addition of new must, and if the scum which collects at the surface is repeatedly removed we have the production of "sweet" wines; on the other hand, if the scum is allowed to remain, so that the fermentation may be more complete, "dry" wines are the result. As the "dryness" of a wine depends upon the completeness with which the sugar of the juice is converted into alcohol and carbon dioxide, it follows that to produce the driest wines fermentation should be



LEAF AFFECTED WITH BLACK ROT

allowed to go on as long as possible. Conversely, it should be possible to produce sweet wines by stopping the fermentation, and this is effected by the fumes of burning sulphur.

There are a great many varieties of white wine, and perhaps the most famous of all is the Rhenish wine known as "Johannisberger," which is grown in Germany. This variety is said to fetch the highest price among white wines, and its reputation has become world-wide. Enormous casks of Johannisberger are lying in the municipal wine cellars of the township of Bremen, the wine being casked and stored in its present position over three centuries ago. This wine, known as "the Rose," is, as one might suppose, the subject of more than one legend, and is offered in hospitality to royalties and persons of distinguished rank who partake in the festivities of the town; it is also graciously given to the sick. Other Rhenish wines of great repute are Rauenthaler, Liebfraumilch, Marcobrunner, Rüdesheimer, Hoheheimer, Kottenlocher, Zetlinger, and Riesling.

The white wines of Burgundy are also highly appreciated, and Montrachet is regarded by some as the king of white wines. Meursault-Goutte-d'Or, Chablis Moutonne, Pouilly-Tuissé are also excellent. Among the white wines of Bordeaux, Château-Yquem is considered the best, and Château-Myrat, Latour-Blanche, Clos St. Marc, and the wines of Sautome, Barsac, and Graves also enjoy a high reputation.

Wines known as pale wines are obtained by pressing the sediment a little more than in the case of the white wines. They possess an agreeable freshness of flavour and are dry, but are liable to turn yellow as soon as they come into contact with the air, a disadvantage which is mitigated by casking as soon as possible.

Light red wines are prepared in the same way as the red wines, with the difference that the sediment is not left in the must longer than twenty-four or forty-eight hours at the most. The right moment for its abstraction is when the larger part of the sugar has had time to be transformed into alcohol, as in the case of the dry white wines, without the wine having acquired too much colour.

A kind of wine is also prepared from dried grapes. This is the case especially in France, where about 100,000,000 kilograms of dried grapes are annually imported, chiefly from Greece. Of these about 4,000,000 hectolitres of wine are prepared, making a wholesome drink, which, however, is less invigorating than wine made from fresh grapes.

All wines, whether red, white or pale, still require a good deal of care after they have been casked. During the second fermentation the chemical processes are continued and facilitated by various means. As fermentation always develops heat, the wine takes up more space while it is fermenting than when the fermentation has abated. Daily the liquid becomes less in bulk, and to avoid contact with the air, which would turn the wine sour, the casks are regularly filled up. Moreover, the wine in the casks only slowly deposits the impurities which it contains, and to facilitate their deposition the wine is drawn off several times either by siphons or small pumps mounted on light carriages. This process is repeated three or four times at intervals of a few months. It is never carried out in the hot weather, when the fermentation is most active.

Notwithstanding these measures adopted for its clarification, the wine contains a good deal of matter in suspension which must be got rid of. The clarifiers employed for this purpose are isinglass, white of egg, and salt: blood and milk are also sometimes used. The action of these clarifiers is purely mechanical: they form a kind of network with narrow meshes at the surface or in the body of the liquor, which slowly sinks to the bottom and carries all impurities with it.

It is then necessary to arrest the fermentation completely. This is accomplished either by the fumes of burning sulphur or, in large establishments, by heating the wine in special vessels to a temperature of 50° to 65° C. All fermentation ceases when the temperature rises above 40°.

Champagne is a wine of so universal a reputation that in any account of viticulture and the wine industry it demands special treatment.

The wine grown in Champagne was early appreciated by connoisseurs, but its modern reputation dates back for three centuries when Dom Pérignon, governor of the abbey of Hautevillers invented the effervescent liquor, which plays so important a part in our festivities.

The manufacture of champagne affords employment to many thousands of people, and the fact that one single house employs more than 3,000 hands concerned in the actual making of the wine will afford some idea of the extent of this branch of the wine industry.

Champagne is manufactured by special methods which demand great care and skill on the part of the operator. The plants themselves which are to yield the grapes destined for this famous wine are chosen from among the very best, and the fruit is most carefully selected. Just as in the case of ordinary white wines, the vintage is taken at once to the press and the juice resulting from the first pressure is reserved for the preparation of the superior qualities of champagne. The lees are then cut up and again subjected to pressure, a process which is repeated two or three times, the juice affording the cheaper varieties of the wine.

The fermentation processes are carried out in large vessels containing about 200 litres of clarified must apiece, the most favourable temperature for the operation being between 16° C. and 18° C. When the fermentation is considered to have gone far enough, the must is drawn off into barrels which have been very carefully cleaned, and later the contents of these barrels are transferred to a gigantic cask where the must is thoroughly mixed by means of a mechanical stirrer. At this stage, should the wine be found to be deficient in alcohol, a quantity of the pure spirit is added and the wine again transferred to casks, where it is clarified by means of the usual agents. When the clarification has reached a certain stage, sugar is added in previously calculated quantities according to the variety of wine desired. The wine is then bottled, corked and wired, and for the next two, three or four years allowed to mature, the bottles being stacked five or six bottles deep. At the end of this period the bottles are taken out and placed on slanting racks with the necks pointing downwards. In the course of time a sediment collects in the bottom of the bottles, and when later the corks are allowed to "fly off," all the impurities are expelled from the bottle by the force of the gas generated. This operation is by no means without its dangers, for it frequently happens that the bottles burst, and it behoves the



SPRAYING VINES WITH A FUNGICIDE

workmen to exercise great caution. The final process consists in adding a small quantity of syrup, the latter being a solution of sugar in old wine, and then the bottles are hermetically sealed, wired, and the cork and neck wrapped round with tinfoil. After labelling, the bottles are again transferred to the cellars, where the wine acquires its effervescing qualities by the generation of carbon dioxide.

As one would naturally suppose, the quality of the champagne will vary with the vintage, and it is the practice to reserve quantities of the wine made from a good vintage for the sole purpose of mixing with the champagne of less favourable years in order to maintain, to a large extent, the average quality of the wine. There are many varieties of champagne, but some of the most famous are Pommery-Greno, St. Marceaux, G. H. Mumm, Moet, Montebello, Heidsieck, Roederer, Mercier, and Cliquot.



GRAPES ATTACKED BY MILDEW



LEAF OF VINE ATTACKED BY PHYLLOXERA

A most important branch of the wine industry is the distillation of alcohol or spirits of wine. One of the chief sources from which alcohol is obtained on a commercial scale is wine, and the distillation of the spirit from wines is confined almost exclusively to France, where the product is largely used in the preparation of the many kinds of brandy. Wine contains from seven to twenty-four per cent. of alcohol, and

TREADING THE GRAPES IN GREECE





WAGGON FOR TRANSPORTING THE GRAPES

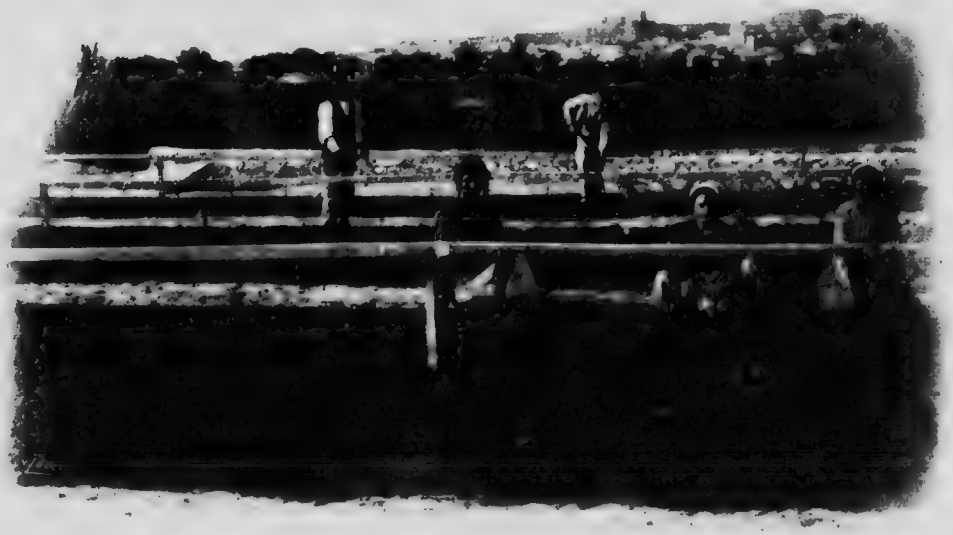
in making choice of the wines to be distilled the first point to be considered is the amount of alcohol which they contain, and then the quality of the spirit which they will yield. The first question is decided by direct testing with a test-still, but as regards the quality of the spirit much depends upon the age, purity, and fineness of the wine employed. White wines are to be preferred, and all the best varieties of "cognac" brandy are distilled from these wines.

A coarser kind of spirit is prepared from the refuse of the wine-press. This refuse still contains a certain amount of sugar, and fermentation is allowed to take place in vats in which the lees are kept at the bottom by means of heavy sieves. After fermentation, which takes about five days, the clear liquor is drawn off and distilled, producing a spirit of a rough, unpleasant odour and flavour. The actual process of distillation is carried out in large stills, a common form of which consists of a boiler containing a series of concentric cylinders so arranged as to effect the separation of the spirituous vapours from the steam. The boiler is heated by a brick furnace, and the vapours condensed by means of an ordinary coil condenser, from which the finished spirit is collected.

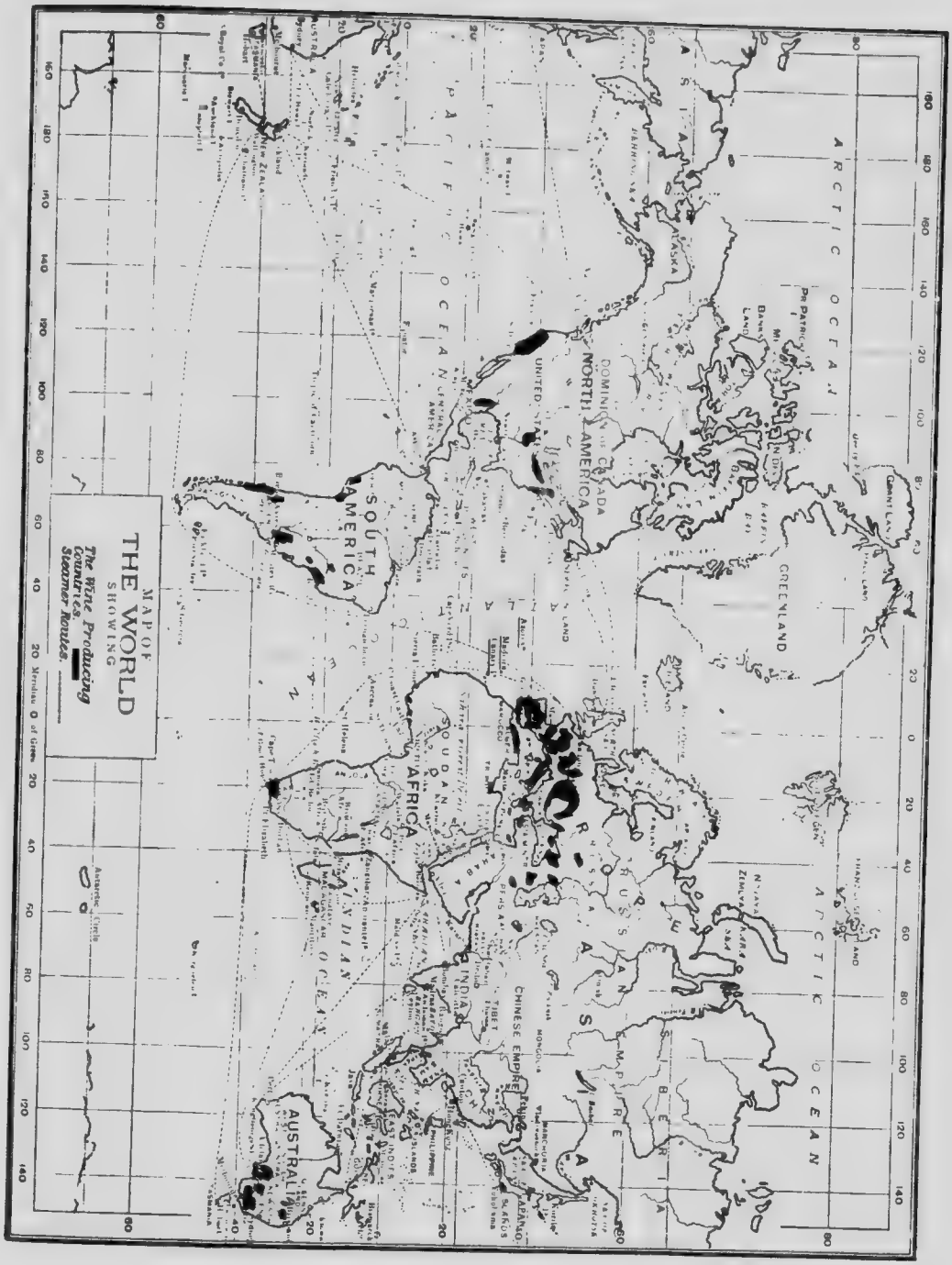
VITICULTURE IN THE BRITISH EMPIRE

Cape Colony

Having thus briefly considered the principal features of the wine industry in France and other parts of the Continent, it will not be out of place to refer to the present condition of



SPREADING CURRANTS TO DRY


MAP OF
THE WORLD
SHEWING
The Wine Producing Countries.
Steamer Routes.
NORTH AMERICA
SOUTH AMERICA
AFRICA
AUSTRALIA
EUROPE
ASIA
GREENLAND
ARCTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
CHINESE EMPIRE
INDIA
RUSSIAN EMPIRE



A PRIMITIVE WINE-PRESS

viticulture in those parts of the British Empire where experiment has shown that it can be successfully carried on. At the outset it will be well to state that the extent of the Colonial wine industry is at present almost negligible when compared with that of Europe and California, but, especially in the case of the Australian states, the industry may be regarded as being as yet in its infancy, and it will be of interest to consider the degree of success which has attended the efforts of our brothers across the seas to enter a field of industry which at one time was regarded, with good reason, as being peculiarly European.

The wine-producing colonies are Cape Colony and the Federated States of Australia. The output in gallons of these countries for 1904 will be seen from the following table, but although the actual amount of wine produced is by no means inconsiderable, it is but a drop in the ocean, being not more than 0·3 per cent. of the world's total production.

PRODUCTION OF WINE IN THE BRITISH EMPIRE, 1904

Cape Colony	5,686,672	gallons
South Australia	2,625,430	,,
Victoria	1,832,386	,,
New South Wales	928,160	,,
Western Australia	187,490	,,
Queensland	60,433	,,
Total	11,320,571	,,

The Cape of Good Hope was the first colony to commence systematic viticulture, and the industry was firmly established by the Dutch long before the country came under the British



AN AUSTRALIAN COOPERAGE



A STORAGE CELLAR AT OPORTO

Crown. It was in 1653 that Van Riebeck, the founder of the first European settlement at the Cape, planted the first vines in Table Valley. The vines were brought from the Rhine vineyards, and since the flourished in their new home, large numbers of plants were brought into the country from Germany and France. Van Riebeck had probably already noted the presence of several species of vine at the Cape, and since it is known that he was a keen observer of Nature, it is highly probable that he early conceived the idea of experimenting in the new country with the vines from Europe.

The earliest account of a vintage is in 1659, and it appears that the Dutch took up the new industry with considerable determination, for we find that in 1681 the first brandy was distilled, and six years later the total number of vines planted in the colony was no less than half a million. By 1710 the cultivation had increased enormously, for, in a report furnished to the Dutch East India Company, we find that the vines planted numbered 2,729,300, and that small quantities of the wine produced had actually been shipped to Europe and Java. At the time viticulture was the most prominent feature of Cape agriculture, and, relatively speaking, was much more important than at the present day. About a hundred years later the number of vines had increased to considerably over twenty-two millions, and the export of wine reached a total of 21,300 pipes. It will come as a surprise to most people to learn that at about this time (1822) England imported more wine from the Cape than she did from France, the actual figures being 11,211 tuns from our neighbours across the Channel and nearly 19,000 tuns from South Africa.



A PORTABLE WINE-PRESS

During the last century the cultivation of the vine was extended, but in spite of the increase in the number and extent of the vineyards, the export of wine gradually diminished, and at the present time wine occupies a very low position in the exports of the country. This undesirable state of affairs has been due largely to the disastrous diseases and pests which have attacked the vines from time to time, and on more than one occasion the industry has been on the verge of ruin. In 1858 the destructive fungus oidium attacked the vineyards and threatened to destroy them, but its ravages were mitigated and finally checked by the vigorous adoption of the sulphur treatment, and the crops were restored. In 1885 the dreaded pest phylloxera appeared near Mowbray, and while at first it was hoped that the disease could be stamped out by the eradication of all vines in the infected areas, it soon became evident that the insect spread too rapidly to cope with its ravages in this way, and the struggle against phylloxera had to be totally abandoned. The vignerons, however, did not despair, but, profiting by the experience of the viticulturists of Europe, commenced the importation of phylloxera-resisting American stocks, the use of which in combating the pest has been described above. At the present time large nurseries of American vines are established at Constantia, Stellenbosch, and the Paarl.

To-day the cultivation of the vine at the Cape is carried on almost exclusively in the western part of the colony, where the climate is probably more favourable to the grape than that of any other part of the world. During the spring there is, in these districts, a sufficiency of brilliant sunshine and rain as will cause a vigorous development of the shoots, and towards the summer, although the sun is in its power, the humidity of the atmosphere is sufficient to allow of the further growth of the bunches which in January and February mature under ideal conditions. By far the most important wine-producing districts of the Cape are Paarl and Stellenbosch, and these are followed in order of their importance by Cape, Malmesbury, Caledon, Robertson, Oudtshoorn, Clanwilliam, Swellendam, Prince Albert, Willowmore, and Uitenhage.

The viticultural districts of the Western Province may be divided into coast and inland districts, differing from one another in the nature of the soil and climate, and hence also in the method of cultivating the vineyards. The soil in the hilly country of the coast districts is derived from the disintegration of granite, sandstone, clay, and slate, and is so retentive of



AN UNDERGROUND WINE CELLAR

moisture that irrigation is quite unnecessary. On the other hand, the inland districts possess a calcareous soil which does not retain the water to so great an extent, and it is necessary to irrigate the vineyards two to four times during the season before the grapes will ripen to perfection. The yield, however, of the inland districts is greatly in excess of that of the coast districts, and the quantity of wine produced is on an average more than double.

With regard to the quality of the wines produced at the Cape it will be sufficient to add that the grapes grown in the colony are of peculiar suitability for the preparation of sweet wines, ports and liqueurs, but that the light wines produced, although steadily improving in quality, are much inferior to those of Europe, and it will be probably long before they obtain a footing in the European market. The inferiority of these wines is largely due to the fact that the first fermentation which is carried out at a high temperature is very tumultuous, and is all over in from four to eight days. It will be remembered that in Europe the same process occupies a much longer period, a fact which allows of a much less vigorous action and the consequent retention of the volatile substances to which the bouquet of the wine is due. In the Cape wines the volatile compounds are expelled during the rapid and boisterous fermentation, and consequently they lack the character which delights the heart of the connoisseur.



MANUFACTURE OF BRANDY

Australia

As will be noticed from the figures already given, the principal wine-producing States of Australia, in order of their importance, are South Australia, Victoria, and New South Wales. Vines were first planted in South Australia between 1840 and 1850, the stocks being obtained from the Botanic Gardens at Sydney, and later from Spain and other parts of Europe. Historically, the most interesting of the vineyards of the colony are those at Reynella, planted by John Reynell, for it was here that, in 1846, the first wine vines were cultivated, and the first wine made. The principal wine-growing districts in the State at the present day are, with the exception of Stanley, nearly all in the Central Division, chiefly in the counties of Adelaide and Light. The soil and climate are very suitable for the production of nearly every kind of wine: the Adelaide plains yield a wine very similar to those of the south of Spain, and the hilly districts produce clarets and other light wines of very considerable quality.

The methods and apparatus employed in the early days of wine-making in the colony were of a very primitive character, and the South Australian vigneron has had to pass through a long and trying course of evolution before he reached the position which at this moment marks him as among the most enlightened wine-makers of the day. The wineries are models of cleanliness, and the fermenting houses are of the most modern type. Spontaneous fermentation is no longer entirely relied upon, but artificial cultures of the fermenting organism are introduced into the must with most satisfactory results. South Australians may pride

themselves with having originated and perfected schemes for treating the grapes, which are now attracting the attention of wine-growers in all parts of the world.

The progress of wine-growing in Victoria has been slow but sure, and in spite of many vicissitudes the production of wine promises at the present day to become one of the greatest industries of the colony. In 1860 the area under vines was about 2,000 acres, and some of the vines had already made their way abroad and obtained favourable recognition. But about this time a great rush for establishing vineyards took place, and in four years over 2,000 acres more were planted by people, the majority of whom had little or no experience of viticulture. The result was inevitable. The wines, made by the most unscientific methods, rapidly came into bad repute, and the trade almost completely died out. Not completely, however, for a few persevering men in the neighbourhood of Melbourne and other large towns, by careful and diligent work, were gradually improving their vintages, and in 1881 created the greatest sensation by winning at the Melbourne International Exhibition the *grand prix* offered by the late German Emperor "to an exhibitor in one of the Australian colonies as an acknowledgment of the efforts in promoting art and industry as shown by the high quality of the goods manufactured by such exhibitor." From that day colonial wine was no longer thrown under general condemnation; it was seen that with careful scientific methods of cultivation and manufacture Victoria could produce wines which were not to be ignored, with the result that the colonists once more turned their attention to viticulture. The most striking testimony to the excellence of Victorian wines has been afforded by some of the most famous growers of Europe—whose names are household words to the connoisseur—who have been forced to admit, generously enough, that many of the Australian wines are to be placed among the best that can be produced.



A COOPER'S WORKSHOP

The manufacture of champagne has engaged the attention of three or four growers in Victoria and New South Wales, and much experience has been gained as to the requirements of the industry under local conditions. Perhaps the best champagne has been produced by the Great Western Vineyard, about 139 miles from Melbourne, where the owner has been assisted in overcoming the great difficulty of regulating the temperature by the possession of huge caverns which have been hewn out of decayed granite rock twenty-five feet

below the surface. Hence the temperature remains at about 58° F., and shows very little variation throughout the year. With many of the difficulties inevitable to a new industry overcome, champagne-making at the present day promises to become an important branch of the Victorian wine industry.

In New South Wales the grape-vine flourishes all along the coast district, especially in the country round Newcastle, and the wines of the Albury district, near the Victorian border, have a high reputation throughout Australia.

The wine-growing industry of the State is still in its infancy, though with a growing local demand, and with the opening up of a market in England, where the wines of New South Wales, in common with those of Victoria and South Australia, enjoy a considerable popularity, the future of grape culture in the colony seems to be fairly assured.

The vine was planted in the early days of colonisation in New South Wales, but it was not until 1828 that viticulture and wine-making became a definite industry of the country. About that time large numbers of stocks were imported from the finest wine-growing districts of Europe and planted in the Hunter River district, and a few years afterwards the Murray River valley received attention. The grapes flourished, but the wines manufactured from them were anything but satisfactory, the reason, as usual, being that the colonists but imperfectly understood the vigneron's art. At the present time however, neither pains nor money are spared to introduce skilled labour and to adopt up-to-date methods, and the results of such intelligent treatment are apparent in the status which the wines of New South Wales hold in the estimation of experts.

VEGETABLES

AMONG the commercial products of the world vegetables are a most important item, and their value as foodstuffs needs no emphasizing. The inhabitants of the world could subsist without animal-flesh, could scarcely subsist entirely on cereals, but they most certainly could not subsist without vegetables. Practically every nation, savage and civilized alike, cultivates a few plants for use as vegetables. The vegetables we know and prize most are one and all the result of long cultivation, the origin of most of them lost in antiquity. The world has been ransacked, and for the vegetables cultivated in the United Kingdom nearly every country under the sun has been laid under contribution.



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WINDSOR CASTLE POTATOES

Large as are the supplies produced in the United Kingdom, they are insufficient for the requirements of the people, and great quantities of raw vegetables are annually imported. In 1905 our imports of these commodities amounted in value to £13,872,842. In 1903 these imports totalled £15,319,994. The average for the last ten years amounts to over £12,300,000 per annum.

POTATOES

The POTATO (*Solanum tuberosum*) is the most important of all vegetables from the point of view of the inhabitants of the British Isles. Its native country and the date of its introduction into Britain have been subjects of much discussion, but there can be no doubt of its being indigenous to various parts of South America—plants having been found in a wild state on the Peruvian coast, as well as on the sterile tracts of Central Chili. The Spaniards are believed to have first brought the potato to Europe from Quito in the early part of the sixteenth century. It afterwards found its way into Italy, and from thence it was carried to Mons in Belgium by one of the attendants of the Pope's legate. In 1598 it was sent from Mons to the celebrated botanist, Clusius, at Vienna, who states that in a short time it spread rapidly throughout Germany. The first potatoes that reached this country were brought from Virginia by the colonists sent out by Sir Walter Raleigh in 1584, and were returned in 1586. They were planted on Sir Walter's estate near Cork, and were used for food in Ireland long before they were even known, much less cultivated, in England. In the time of James I they were so rare as to cost 2s. per pound, and are mentioned in 1619 among the articles provided for the Royal household. In 1633, when their valuable properties had become more generally known, the Royal Society took measures to encourage their cultivation with the view of preventing famine. However, it was not until nearly a century after the above date that they were grown to any great extent in England. In 1725 they were introduced into Scotland and cultivated with much success, first in gardens and afterwards (about 1760) in open fields.



GARDEN CABBAGE

In a wild state the tubers of the potato are very small, seldom exceeding the size of a walnut. Under cultivation the plant has vastly improved and varieties innumerable have been raised. These varieties differ considerably not only in size, form and colour, but in the length of time taken to mature, and in being either waxy or dry and floury. It has been found that when a particular variety has been grown in the same soil for any length of time it degenerates and requires to be renewed either by seed, but more frequently by resorting to "sets" of sorts which have been grown in different soils and locality. In this way varieties are continually changing, and nearly every town or district has its particular favourite.

Whilst the potato can be cultivated in almost any kind of soil and under widely different conditions, and after planting with a minimum amount of attention, it nevertheless responds to generous culture. A rich, light, warm soil suits it best, heavy cold soils being least desirable. The "sets" may be planted any time from February to the end of May, but March and early April are the best times. They should be planted in trenches four to six inches deep—allowing six inches between each set with the early kinds, to twenty inches with the late kinds. The trenches should be eighteen inches apart for the small-growing early kinds, and thirty-six to forty inches for the strong-growing late kinds. The potato being a sub-tropical

plant will not withstand frost, and the early kinds should be afforded some protection if late frost occurs after the shoots are above the soil.

The ground should be kept free of weeds, and when the shoots are about six inches high soil should be drawn up around them. The potato tuber is really a thickened underground stem borne at the ends of runners which originate in the axils of the lower stem leaves. By earthing up the stems the production of these is promoted and a heavier crop results.

In 1845 a devastating disease made its appearance amongst potatoes in this country and threatened the entire destruction of the crop. This disease proved to be due to a Fungus (*Phytophthora infestans*), which first attacks the leaves, causing discoloration, and thence rapidly spreads down the stems to the tubers. Whilst no actual cure is at present known, spraying the crops at intervals with a solution of copper sulphate and lime (Bordeaux mixture) will check the disease if not actually destroying it. Some varieties of potatoes are capable of resisting disease to a very considerable extent until they become degenerate. A disease-proof potato is a desideratum which plant breeders are endeavouring to fill. At present there is no such a thing absolutely, any more than there is a disease-proof wheat, dog, horse, or man. By a continual change of stock, care to plant only the best varieties, and judicious spraying, the disease can be kept in check if not in abeyance.



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BORECOLE OR KALE

The cultivation of the potato is now carried on in practically every part of the world—from Iceland to New Zealand, in Africa and distant China. In this latter country it was introduced by Roman Catholic missionaries some thirty years ago, and though despised by the rice-eating Chinese of the south, the potato has become a staple food of the peasants in the more mountainous parts of the Empire.

In Great Britain and Ireland the potato is one of the most important crops. In 1905 no fewer than 1,225,228 acres were planted with potatoes.

Lincolnshire, Yorkshire and Lancashire are the chief potato growing counties in England, followed by Cambridgeshire and Cheshire. Fifeshire, Forfarshire, and Perthshire are the principal Scotch counties. In 1905 the total yield for Great Britain and Ireland was 7,185,745 tons—the average yield per acre for the last ten years being 4·84 tons.

In the same year Great Britain imported 3,664,290 cwt. of potatoes valued at £1,404,607.



THE GRAPE-VINE

Of the total imports 2,525,741 cwt. were from foreign countries, and 1,138,549 cwt. from British possessions. Nearly the whole of our imports consist of early new potatoes.

SWEET POTATOES AND YAMS

In tropical countries sweet potatoes and yams take the place of the ordinary potato. Yams, the tubers of various species of *Dioscorea*, are cultivated in nearly all tropical countries as important esculents. The Black Bryony of our hedgerows is a close relative of the yams, and has a large underground tuber which, however, is of no use as a food. Yam tubers abound in farinaceous matter and often reach a large size, weighing as much as from thirty to sixty lbs.

Sweet potatoes are the thickened roots of *Ipomoea Batatas*, a climbing plant belonging to the Bindweed or Convolvulus family. This plant is extensively cultivated in most tropical countries, although not known in a wild state. The root contains much starch and saccharine matter.



CELERY

OTHER EDIBLE TUBERS

ARRACACHA (*Arracacia esculenta*), a plant allied to the parsnip and carrot, is extensively cultivated in the Andes, and has become naturalised in Jamaica.

Under the name of "Crosnes" the tubers of *Stachys tuberifera* were introduced into this country by way of France from Northern China in 1887.

JERUSALEM ARTICHOKES, the tubers of a sunflower (*Helianthus tuberosus*), originally introduced in the early part of the seventeenth century from the Northern United States of America, are widely cultivated as an article of food.

PULSES

These are all members of the Pea family, and are among the most important of foodstuffs; they are cultivated and used in large quantities in all parts of the world. In countries like India and China, where, relatively speaking, very little meat is eaten by the natives, pulses are an absolute necessity of life, constituting the chief nitrogenous foods. Before the spread of



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EXPERIMENTAL PLANTATION OF POTATOES

the potato, pulse (chiefly peas) formed a great part of the food of the working classes of the United Kingdom, and more especially in England. So important was this crop considered that in the letting or taking of a farm the acreage of Siddaw land (the term by which land that would grow good boiling peas was known in Gloucester, Hereford, and Worcester) was always taken into consideration. In 1905 no fewer than 428,497 acres of agricultural land in the United Kingdom were occupied with peas and beans, the total yield for 1905 being 12,707,747 bushels. In addition to this we imported in 1905, 3,240,926 cwt. of peas and beans, our average annual imports of these commodities for the last ten years being 4,374,220 cwt.

PEAS

The Common Pea (*Pisum sativum*) has been cultivated from very remote times. The pea plant is covered with a delicate glaucous bloom, and its white or pale violet flowers are familiar to all. The pods are pendulous, smooth, deep green, and variable in size and may contain any number up to thirteen (rarely more) peas. The peas when ripe are also variable, some being white and round, others blue and wrinkled, and a few large, irregular, and dull green.

Besides the varieties of peas whose seeds are edible, there is a section denominated "sugar peas," the members of which are destitute of the inner film peculiar to the pods of other kinds. They are consequently more fleshy and crisp, and admit of being cut and dressed in exactly the same manner as French beans. This species is more popular in France than in this country.

Field Peas. The original Grey Pea is supposed to be wild in Greece and the Levant, and is probably the original parent both of the few sorts of peas grown by the farmer and the countless numbers of still increasing kinds of the garden.

In 1905, 172,931 acres in the United Kingdom were under peas, the total yield being 4,446,050 bushels. Of the total acreage, England's share was 171,110 acres.

The average yield in the United Kingdom for the past ten years was 26·24 bushels per acre. Our total imports of peas for 1905 was 2,015,876 cwt. Of these 1,056,360 cwt. came from British possessions.

BEANS

Broad or Horse Beans rank with peas as the most important pulse crop cultivated in or imported into this country. The common bean is a hardy annual, generally believed to be a native of the shores of the Caspian Sea, as well as of Egypt and other parts of the Orient. The acreage under beans in the United Kingdom in 1905 was 255,566 acres.

The total yield in 1905 in the United Kingdom was 8,261,697 bushels: the average yield per acre for the last ten years being 27·68 bushels per acre. The principal counties are Suffolk, Lincoln, Essex, and Cambridge. Beans are in important import into this country. In 1905 it amounted to 1,225,050 cwt. Of these 200,440 cwt. came from British possessions.

TROPICAL AND SUB-TROPICAL PULSES

Whilst peas and beans are practically the only important pulse crops grown in this country, in tropical and sub-tropical countries their name is legion, and several demand more than mere passing notice in these pages.



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NOVA SCOTIA. A FIELD OF ROOTS



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MUSHROOMS

GRAM or CHICK PEA (*Cicer arietinum*), an annual herb, cultivated from an early period in warm countries, especially in India, where it is used in cakes, curries, etc. Gram was known to the ancient Egyptians, Hebrews, and Greeks. The Persian weight, *Nukhud*, $\frac{1}{144}$ oz. Avoird., is that of a seed of *Cicer arietinum*. Gram is exported in considerable and increasing quantities from India; the average for the last five years being 422,436 cwt. In 1904-05 India exported 777,297 cwt. of gram valued at £178,993. Of this no less than £98,954 worth went to France.

LENTILS (*Ervum Lens*), a slender plant supposed to be native of Western Asia, Greece, and Italy. The Lentil was introduced into Egypt as a cultivated plant at an early date, and from this centre spread east and west. Large quantities of lentils are introduced into this country and used for soups, etc.

The SOYA BEAN (*Glycine hispida*), a dwarf, bushy, almost erect plant, with every part covered with fine brownish hairs. The Soya Bean is widely cultivated in India, and more especially in China and Japan, where it is probably native. In the Far East "Soya" constitutes the most important pulse.

PIGEON PEA or DHOL of commerce (*Cajanus indicus*) is an erect sub-shrubby plant, often about six feet in height, widely cultivated in the tropics and sub-tropics of both hemispheres. The pea-like seeds are of two kinds—yellow and veined with purple. Considerable quantities are imported into Britain for use as cattle foods.

COW PEA (*Vigna Catiang*). This is a very curious plant, with long, almost cylindrical, pods one to two feet long. These pods are often gathered when green, cut into lengths, cooked and eaten like ordinary "kidney beans." The seeds are also largely used as food in the tropics.

LABLAB (*Dolichos Lablab*), a tall climber, native of India, very similar to the common "kidney bean," but with the flowers dark purple and clustered at the ends of long stalks.

GREEN GRAM or MUNG (*Phaseolus Mungo*), a native of India, where it has been cultivated for some 3,000 years. It is grown all over the Indian peninsula in immense quantities. The green pods are eaten as a vegetable; the ripe pulse is used boiled whole or split like Dhol. Parched and ground into flour it is used in a variety of ways. Green Gram is valued as a horse and cattle food, being considered fattening. The stems are crushed and used as fodder. *Phascolus Mungo*, var. *radiatus*, is the most esteemed of all pulses in India, and fetches the highest price in the market. A native of India, it has been cultivated from time immemorial. It differs from the type (*P. Mungo*) in its longer trailing habit, greater hairiness, and in the seeds being fewer, larger, longer, and usually of a dark-brown colour.

SCARLET RUNNER (*Phascolus multiflorus*), a native of South America, and said to have been

introduced into Britain in 1633. Though usually considered to be a half-hardy annual and treated as such in gardens, it is really a tender perennial, having tuberous roots.

Common Kidney or French Bean (*Phaseolus vulgaris*), is of uncertain origin, probably Asiatic, and is very generally cultivated in Europe and other temperate climes. As the result of long cultivation many varieties have originated, some dwarf in habit, others tall: in some it is the seeds that are valued, in others the pods. In this country it is the young green pods which are most valued as a vegetable.

THE CABBAGE FAMILY

This family comprises some of the most ancient of culinary vegetables: they are rich in sulphur, and possess antiscorbutic properties. The cabbage is found in a wild state in various parts of Europe and in southern England, always on maritime cliffs. It is a biennial, with fleshy lobed leaves covered with a glaucous bloom: altogether so different in form and appearance from the cabbage of our gardens that few would believe it could possibly have been the parent of so varied a progeny as are comprised in the Savoy, Brussels Sprouts, Cauliflower, Broccoli, and other numerous varieties.

The Common or Cultivated Cabbage is well known, and from a very early period has been a favourite culinary vegetable in almost daily use throughout the civilised world.

The Savoy Cabbage differs but little from other hearting cabbages. It is chiefly distinguished by its leaves being wrinkled in such a manner as to have a netted appearance.

Brussels Sprouts, or Bud-bearing Cabbage (*B. oleracea bullata minor*), originated in Belgium, and has been cultivated around Brussels from time immemorial, although it is only within the last fifty years that it has become generally known in this country.

Borecole (*B. oleracea acephala*) has every appearance of being one of the early removes from the original species. It is distinguished by its leaves being beautifully cut and curled, of a green or purple colour, or variegated with red, green, and yellow, never closing so as to form a heart, nor producing edible flower heads like a Cauliflower.

Couve Tronchuda or Portugal Cabbage (*B. oleracea costata*) is a variety peculiar to Trauxuda, in Portugal, from whence it was introduced in 1821 to Britain. This is a singular cabbage with much thickened midribs which, when thoroughly boiled, make an excellent vegetable for serving up after the manner of Seakale.

The Cauliflower (*B. oleracea botrytis cauliflora*) is of great antiquity, but its origin is unknown, although it is usually ascribed to Italy. It was introduced to Britain during the sixteenth century. In the cauliflower it is not the leaves



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CHILI AND CAPSICUM



HOEING PUMPKINS

but the flower-buds and fleshy flower-stalks, which form a close, firm head, four to eight inches across, that are valued. Whiteness and compactness and not mere size are the qualities esteemed.

Broccoli (*B. oleracea botrytis asparagoides*) is similar in form and appearance to the cauliflower, from which it is supposed to have originated. Several varieties of Broccoli are cultivated which vary in degree of hardiness and length of time taken to mature.

Whilst the above are the varieties of cabbage best known to us, there are many other varieties cultivated in different parts of the world. One of the most interesting is the Chinese Cabbage.

The Turnip (*Brassica Rapa depressa*) is a hardy biennial, and, in its wild state, is found in cornfields in various parts of England. The change it has undergone by cultivation is no less remarkable than that of the cabbage, but in this instance it is the root which has been transformed from a comparatively hard woody substance into a fleshy and nutritious vegetable.

Many varieties of turnip are known, some with round, others with long roots. The smaller kinds are valued in gardens as a vegetable, and the larger as field crops for cattle.

The Swede is a yellow and very firm-fleshed kind of turnip, introduced into Britain from Sweden. It is the *Brassica campestris rutabaga* of botanists, and is a valued agricultural crop in this country.

Mangel Wurzel (root of scarcity) is the white form of *Beta maritima*, a plant found wild on the rocks and the seashores in Europe, Western Asia, and Northern Africa. In Britain it is not uncommon on the coasts south of Fife and Argyle. Sea Beet is a perennial, and has undergone remarkable changes under cultivation. The Red Beet is one form which is valued as a vegetable and salad in this country, but much more so in France and Germany. A variety of Red Beet is the source of Beetroot sugar.

The Tomato is an annual plant, native of the warmer parts of America, but long ago introduced into most other warm or temperate countries. The fruits of the tomato are red or yellow, and vary very much in size and shape, some being not larger than good-sized red currants.

The Brinjal or Aubergine (*Solanum Melongena*) is closely allied to the tomato.

The Onion (*Allium Cepa*) is a bulbous plant allied to the lilies, and has been known and cultivated as an article of food from the earliest period.

Many other important vegetables are allied to the onion, viz.: Leek, Shallot, Welsh Onion, Chives, and Garlic. All of these are highly valued in this and other countries. The garlic in some countries, especially China and the Far East, is the most highly esteemed of all.

The Cucumber (*Cucumis sativus*), is native of Asia and Egypt, where it has been cultivated for more than 3,000 years. It was known in England in the time of Edward III (1327), but its culture was neglected until the time of Henry VIII. Since then it has gradually increased in public favour until the present time.

The VEGETABLE MARROW (*Cucurbita ovifera*) is closely allied to the cucumber, and is supposed to have been originally brought from Persia. Like the cucumber it is a tender annual, but succeeds out of doors in summer in this country.

Many other members of the cucumber family are cultivated as esculents, notably in the warmer parts of the world. Of these the chief are Pumpkins, Melon Pumpkin, Wat Melon, Chocho, Bottle Gourd, Squash.

ASPARAGUS (*A. officinalis*), a native of maritime parts of south-west England, is abundant in parts of Russia and Poland. It is also common in Greece and was esteemed as a vegetable by the Greeks and Romans by whom it was cultivated about 200 B.C. In this country asparagus is reckoned among the oldest and most delicate of our culinary vegetables. Forced asparagus was supplied to the London market as long ago as 1670.

CAPSICUMS or CHILLIES (*Capsicum annuum* and *C. frutescens*) are widely cultivated in the warmer parts of both hemispheres. The fruits vary considerably in shape and size, and when green are cooked and eaten as a vegetable.

CARROT (*Daucus Carota*), a biennial, native of Britain, is usually found in its wild state in light, sandy soil. It was introduced into England during the reign of Queen Elizabeth, and first cultivated in the neighbourhood of Sandwich, Kent.

PARSNIPS, the roots of *Peucedanum sativum*, a biennial, is a native of marshy places in Britain and elsewhere. The parsnip is closely allied to the carrot, and has been cultivated as an esculent from a very early period.

CELERY. Allied to the carrot and parsnip is the widely different-looking vegetable, celery (*Apium graveolens*). In a wild state the celery is found in the marshy places by the sea in England and Ireland. The blanched stalks are eaten as a vegetable.

FRUITS

OUR annual import of raw fruits and nuts is an increasing one, and the average for the last ten years is estimated at £8,267,346 value annually. Canada, Australasia, West and East Indies, and latterly Cape Colony grow quantities of fruit for export to the United Kingdom. But the continent of Europe, the near Orient, and the United States of America supply the bulk of our imports Since the advent of cold storage the importation of fresh fruits from distant parts of the world has become simplified. Nowadays many steamship and railway lines cater especially



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THE MELON



NATAL. GROWING PINEAPPLES

for fruit traffic, and, though there is still plenty of room for improvement in these matters, those interested are keenly alive, and increased facilities may be reasonably expected.

ORCHARD FRUITS

The APPLE (*Pyrus Malus*) is native to most of the countries of Europe, and is also found in the region of the Caucasus. In its wild state it is known in Britain as the crab, and from this the vast number of cultivated varieties have originated. The cultivation of the apple extends to the most northern extremity of Britain, and in Scandinavia as far north as lat. 65°. Whilst the apple-tree is amongst the hardiest of our fruit-trees, its blossoms are very susceptible to frost, and late May frosts often make sad havoc of the apple crop in this country. Although the apple exists in high latitudes, its fruit there is small—not from excessive cold in winter, but for want of sufficient heat in summer. In Nova Scotia, where the winters are long and intensely cold and the summer short but very hot, the apples are large and of splendid colour. In tropical climates the apple does not succeed, but in the temperate regions of both hemispheres it is very extensively cultivated. In the northern and middle regions of the United States of America and in parts of Canada, as in British Columbia, the produce is very fine. Parts of Australasia, notably Tasmania, produce very fine apples, and their culture is now successfully carried on in Cape Colony.

Although apples are grown in most parts of Great Britain, the bulk are produced in the counties of Kent, Hereford, Devon, Somerset, Worcester, and Gloucester. The apple is the principal orchard crop in Great Britain, but the yield is quite insufficient for our needs, and huge quantities are annually imported. In 1905 we imported 3,494,660 cwt. of apples, valued at £2,065,193. Of these 2,005,428 cwt. were from foreign countries, principally the United States, and 1,489,232 cwt. from British possessions, particularly Canada.

The PEAR is less hardy than the apple, and requires more sun to perfect its fruits. In this country the best pears are obtained from trees grown against walls and sheltered from the cold winds. Most of the best varieties originated in France and Belgium, especially in gardens attached to religious establishments, and were introduced into England and other countries after the Battle of Waterloo.

The pear is now almost as widely cultivated as the apple, and shares the same regions of the world. In California fruit-canning is a big industry, and everyone is familiar with Californian tinned pears. The variety used, the so-called Bartlett Pear, is none other than William's "Bon Chrétien," one of the best early pears extant.

The imports of pears into the United Kingdom in 1905 amounted to 417,919 cwt., valued

THE MANGO TREE

at £407,817. Of these 401,237 cwt. were from foreign countries, chiefly France and the United States.

The MEDLAR (*Mespilus germanica*), LOQUAT (*Eriobotrya japonica*), and QUINCE (*Cydonia* spp.), are all closely allied to the apple and pear. The fruit of the medlar is edible when well bletted, but is not so popular in Europe as formerly. The Loquat yields a small roundish or pear-shaped fruit, orange-yellow in colour, and pleasantly acid. It is a native of China and Japan, and commonly eaten there. The common quince (*Cydonia vulgaris*) is native to Southern Europe and Algeria, where it has been cultivated from time immemorial for its fruits, which were much revered by the ancients. Their chief use is for making jelly, which is highly esteemed, especially in Canada and the United States of America. The name marmalade is said to be derived from "Marmelo," the Portuguese name for quince. The plants are much used in England and the Continent as stocks for pear trees, especially those intended to be kept dwarf.

STONE FRUITS

The PLUM (*Prunus domestica*) is a native of the Caucasus and Asia Minor, naturalised in Greece and in most of the temperate regions of Europe. Cultivated varieties, according to Pliny, were brought from Syria into Greece and thence into Italy about 232 B.C.



TRINIDAD, CUSTARD APPLE

Many of the best varieties of plums cultivated in Britain were introduced from France and Italy centuries ago. The Orleans Plum, for instance, is supposed to have been brought over when the English held possession of that French city during the reign of Henry V.

PRUNES are dried plums prepared in France, Germany, and other parts of the continent. The neighbourhood of Tours, in France, is celebrated for its prunes. The prunes which come from the south of France are prepared from a variety called "Perdrigon." German prunes are prepared from an oblong purple variety called "Zwetsche."

The DAMSON, a small oval, purple plum, is very largely cultivated in this country for making into preserves. The damson is highly productive and more hardy than the ordinary plum

Plums are widely grown in Britain, especially in



MYSORE—A GIGANTIC MANGO TREE.

certain districts like Kent and the Vale of Evesham, but owing to late spring frosts which frequently prevail the crop is very uncertain. The bulk of our supply comes from France and Germany.

The APRICOT (*Prunus Armeniaca*) is supposed to be native to Armenia, but is now naturalised in India, China, Egypt, and other parts of the world. The apricot was introduced into cultivation in Italy about the beginning of the Christian era; from Italy it is said to have been introduced into England by Woolf, gardener to Henry VIII, in 1534. The apricot thrives in California and other parts of the United States of America. In Australia it is successfully grown, and quite recently most excellent apricots have reached this country from Cape Colony. There are many varieties: one, the *Mush-Mush*, with sweet kernels, is grown in the oases of Upper Egypt, where the fruit is dried and forms an article of commerce. Dried apricots are also prepared in northern India, and find their way across Tibet to Western China, and are esteemed by Tibetans and Chinese alike. The apricot is somewhat extensively grown in France, and from there we draw the bulk of our supply.

The PEACH (*Prunus persica*) is the most esteemed and luscious of fruits of the plum tribe. It is, in all probability, a native of China, where it has been cultivated from a very remote period. From China peach-stones were probably carried by the old trade route to Bokhara and Persia. From Persia the peach was introduced into Asia Minor and Europe somewhere about 300 B.C.

There are three distinct forms of peach—*clingstones*, *freestones*, and *nectarines*—and numerous varieties of each form. English-grown peaches are preferred in this country to those of any other land, and in every garden of importance greenhouses and walls are devoted expressly to the culture of this delicious dessert fruit. The imports of peaches into this country, like those of

apricots, are small, and come chiefly from France. A few come from the United States, Canada, and, latterly, from Cape Colony.

CHERRIES. The numerous varieties of cultivated cherries have in all probability originated from *Prunus Avium* and *Prunus Cerasus*. Those belonging to *P. Avium*, of which the Bigarreau and the Black Heart may be instanced as typical of the better kinds, have generally larger, thinner, and more pendulous leaves, and fruits more yellowish-green in colour than those of *P. Cerasus*. From this latter species are derived such well-known varieties as May Duke, Kentish, and Morello, with red, dark red, or nearly black juicy fruits. Both species are natives of Europe and parts of Asia, and are very widely cultivated. The cherry is one of the commonest fruit trees in Britain, and in some parts, notably Kent, great quantities are grown. It is said that the present race of cherries cultivated in Britain was introduced from Holland and Belgium during the reign of Henry VIII.

Large quantities of cherries are annually imported into this country from France; less quantities from Germany, Netherlands, and Belgium. Occasionally small consignments arrive from Canada.

SMALL FRUITS

Red Currants (*Ribes rubrum*) and Black Currants (*R. nigrum*) must not be confused with the dried currants of the shops, which are the fruits of a kind of grape. Both red and black currants are natives of northern and central Europe, and extend across northern Asia to the shores of the Pacific. They are very hardy, and their culture has been carried on in Britain and northern Europe generally from remote times. In spite of the large quantities grown



JAMAICA. A TYPICAL PINERY

in this country we import currants in considerable quantities from the continent of Europe principally France, Netherlands, and Belgium. In 1905 our imports of currants amounted to 82,283 cwt.

The GOOSEBERRY (*Ribes Grossularia*) is found wild in this country and in many other parts of Europe; it extends eastwards to the borders of China and in Eastern Tibet is commonly used as a hedge-plant. The plant is very hardy, and in Norway its successful culture extends as far north as lat. 68°. Cool climates suit it best, and in the north of England and Scotland it thrives better than [illegible].

The gooseberry has many local names even in this country. In Scotland it is called "Grozet," in France "Groseille" (the French use the fruit for making a sauce for mackerel); to the Germans it is the "Kraused beere" or "Stachel-beere," to the Dutch "Kruisbes" or "Kruisbezie," to the Danes and Swedes the "Krusbaar."



THE GUAVA TREE

The RASPBERRY (*Rubus Idaeus*) is closely allied to the blackberry of our hedgerows. A native of Britain and most of the countries of Europe, the raspberry grows wild as far north as lat. 70° and southward in Asia Minor to lat. 39° 40'. This fruit was well known to the ancients, and has been cultivated from time immemorial.

Many species of Rubus have been taken in hand by horticulturists and hybridists, and some valuable fruiting kinds raised. One, called the Loganberry, raised in America, has gained a wide reputation for its fine fruits. The Japanese Wine-berry (*R. phœnicolasius*) is cultivated in Europe and America for its ornamental appearance as well as for its edible fruits.

The MULBERRY (*Morus nigra*) is a small tree belonging to the stinging-nettle family. The fruits are black, luscious, and vinous, and were formerly much more esteemed in this country.

The STRAWBERRY (*Fragaria virginiana*) is one of the most familiar and prized of all English-grown fruits. A native of Virginia, it was introduced into this country in 1629, and has been cultivated in increasing quantities ever since. Formerly, the immediate neighbourhood of London—Mortlake, Twickenham, and Isleworth was a great strawberry-growing district, but, owing to the demands of the builder, the cult has been removed farther afield. Parts of Hampshire, Cambridge, Surrey and Kent are noted for their strawberries.

The strawberry crop is one of the most certain of all crops in this country, provided the plants are properly looked after, and not allowed to suffer from drought. They "force" well, and the early English strawberries of the shops are all grown in pots or frames under glass.

The strawberries consumed in this country are chiefly home-grown; France and the Netherlands are the only countries from which we import any appreciable quantity.

EXOTIC FRUITS

The COMMON ORANGE, also known as the Sweet or Chinese Orange (*Citrus Aurantium*), is probably a native of China, where it is widely cultivated. This orange forms a low, very bushy, evergreen tree with very hard wood, and lives to a great age. The fruits are borne in great profusion, and orchards of orange-trees loaded with ripe fruits present one of the most beautiful sights imaginable. In favoured spots in the south-west of England oranges succeed against warm walls protected in winter, but they are usually grown in structures termed "orangeries." Owing to the indifferent results, the expense involved, and the ease and cheapness with which oranges can be imported from south Europe and elsewhere, their culture in this country has been practically abandoned.



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A FRUIT RANCH AT LOS ANGELOS, CALIFORNIA

Under favourable circumstances the productiveness of the orange is astonishing. In the island of St. Michael a single tree has been said to produce 20,000 oranges fit for exportation! There are many varieties of this orange as the result of its wide cultivation; some are of great value, others of but little merit. Among the more familiar and esteemed are the Blood Orange, Saint Michael's, and Sweet-skinned Oranges. The blood orange has a round fruit, rough red or reddish-yellow outside, with a pulp irregularly mottled with crimson. The St. Michael's Orange has a rather small fruit, pale yellow and seedless, with a very thin rind and very sweet pulp. The sweet-skinned orange is the Forbidden Fruit ("Pomme d'Adam") of the Paris shops, but not of London. The rind is smooth, deep yellow, very thick, and sweet.

The SEVILLE or BITTER ORANGE (*C. Aurantium*, var. *Bigaradia*) was introduced into Arabia, like the sweet orange, from India by the Arabs in the ninth century. From Arabia it was carried by way of Egypt and north Africa to Spain, probably by the Moors. It was in cultivation at Seville about the end of the twelfth century. The fruit of the Seville orange is round, dark-coloured, with an uneven, rugged, and very bitter rind. The fruit is largely used for making marmalade, and the rind for making candied orange peel. The ripe fruit is also made into a syrup, and is one of the principal ingredients of the liqueur Curaçoa.

A SOUTHERN CALIFORNIAN ORANGE TREE

From Stereograph (copyright photograph) ... published by Underwood & Underwood, N. Y.

The BERGAMOT ORANGE (*C. Aurantium*, var. *Bergamia*) produces small pyriform fruits, the pulp of which is acid and bitter ; the rind is thin, golden yellow, and filled with a sweet essence. Formerly, sweetmeats called *bergamottes* were made of it ; now it is only used for the expression of oil of bergamot. This variety is chiefly cultivated in the South of France, in Sicily, and near Reggio in South Calabria.

The MANDARIN or MALTESE ORANGE (*Citrus nobilis*) is a native of China, but is now as widely cultivated as the sweet orange. In Malta and the Azores this orange is very successfully cultivated. The fruit is small, flattened, with a thin rind which separates spontaneously from the pulp, so that when quite ripe the latter may be shaken about inside. The pulp is exceedingly rich and sweet ; unfortunately this variety does not keep so well as the ordinary orange. The Mandarin orange is largely grown in China, and certain districts, notably Swatow, are famed for this variety.



THE MANGO FRUIT

Oranges form the largest item in the fruit imports of the United Kingdom. In 1905 our total imports were 5,068,526 cwt., valued at £1,949,496.

The total imports of oranges from British possessions was only 104,901 cwt. : of these no fewer than 103,257 cwt. were from the West Indies, which produce excellent fruit.

The CITRON (*C. medica*) has been found wild in the Khasia Hills and other parts of northern India. It is cultivated in China, Cochin China, and in all the warm, moist parts of India. It reached Europe by way of Persia. The Jews cultivated the citron at the time they were under subjection to the Romans, and used the fruit then, as now, in the Feast of Tabernacles. At the present day the citron is cultivated in Sicily, Corsica, Italy, Spain, Portugal, West Indies, and Brazil.

The inner rind of the citron is thick and fleshy, and a pleasant preserve is prepared from it. Candied citron rind is well known.

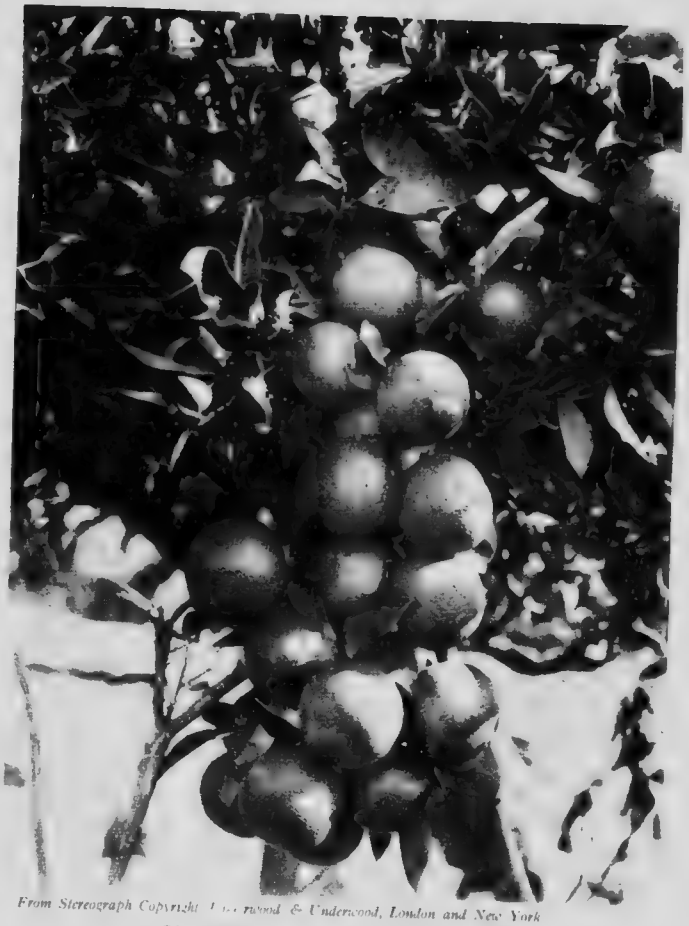
The LEMON (*Citrus medica*, var. *Limonum*) is possibly a native of India or China, but its original habitat is uncertain. It is cultivated in the above countries, and found its way to Europe from India about a century after the orange.

There is a considerable import of lemons into the United Kingdom. In 1905 our total

imports were 837,028 cwt., valued at £419,049. Of these, 834,884 cwt. were from foreign countries, chiefly from Italy. Of the total imports from British possessions (2,184 cwt.) West Indies contributed 2,088 cwt.

The LIME (*C. medica*, var. *acida*) is native to the warm valleys of the outer Himalaya; it is cultivated in India, Burma, West Indies, etc. In the West Indies the cultivation of the lime is now conducted on a large scale for the sake of the juice, which is imported into this and other countries in large quantities. Green limes are also in considerable demand, especially in the United States of America. The ordinary lime is a very spiny tree, but a variety originated at Dominica in the West Indies is absolutely spineless. A seedless lime has been discovered in Trinidad.

The SWEET LIME (*C. medica*, var. *Limetta*) is a native of Southern India, where it is also cultivated. Sweet limes are eaten fresh or preserved. The juice is not so much valued as that of the Sour Lime.



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CALIFORNIA. AN ORANGE CLUSTER

The SHADDOCK (*C. Decumana*) is native of the Malay Archipelago, the Friendly Islands, and Fiji. The fruit is very large, weighing sometimes from ten to twenty pounds, roundish or oblong, with a smooth, pale-yellow skin, and white or reddish sub-acid pulp.

The "Grape Fruit" of the West Indies is also a superior variety of this same species.

BANANAS. The banana has during the last few years advanced rapidly in popularity in Great Britain. The old-established kind is the China or Canary Banana, the fruit of *Musa Cavendishii*, originally discovered in China, but now cultivated in many parts of the world. The more recent introduction, the large banana, is usually known as the Jamaica banana, the supplies coming from there, from Costa Rica, and neighbouring places. This is the fruit of another species, *M. sapientum*, var. *paradisiaca*, also probably an Asiatic plant.

The cultivated banana is seedless (indicative of the ages during which it has been grown), and propagation is effected by cuttings. The plants form below ground a huge rootstock, which gives off suckers or shoots. One of these cut off with a piece of the rootstock and set in the ground grows very rapidly, forming a plant of the habit shown in the illustration, with large, broad, deep-green leaves, at first entire but which soon split into innumerable strips when exposed to wind.

The China or Canary Banana plant is usually about four or six feet in height. Large quantities of this variety are cultivated in Madeira and the Canary Islands, and most of the market supplies are derived from these sources. The fruits have to be cut before they are ripe, and the best time is when they have lost their early angularity and have become round and full, but are still quite green. They are carefully wrapped in cotton wool, paper, dry banana leaves, and packed in open sided crates. They can be carried on the decks of steamers or in a cool room to the receiving port; ripening continues during the voyage so long as the fruit is not exposed to either too high or too low a temperature.

The Jamaica banana is a much larger plant, often twelve feet or so in height. The fruit is larger also, and having a thicker skin it can be shipped without the expense of the costly packing in crates being necessary. Ships with specially fitted rooms are provided on the Direct West India Service, and in these the bunches are placed loose. Bananas are now the chief export of Jamaica, the annual trade being over £1,000,000, chiefly with the United States.

Recently an effort was made to export bananas from Barbados to England. The Canary method of packing was adopted, and the fruits arrived in England in good condition and realised high prices. Improved shipping facilities are the principal requisite to ensure a successful trade.

A dull, purple-coloured banana is sometimes to be seen in the fruiterer's. This is the Claret Banana. It is not to every taste of such good flavour as the preceding, but is in certain demand owing to its colour, which makes it an interesting addition to table dessert.



By permission of the Canadian Government

YOUNG APPLE TREE AT CANADIAN GOVERNMENT FARM

The GRAPE (*Vitis vinifera*) is the most esteemed of all dessert fruits. In this country a great many varieties of grape are cultivated, practically all under glass, and English hot-house grapes are considered the finest grapes in the world. Elsewhere in this work the vine is treated at length, and it is sufficient in this place to note its value as a fruit.

Considerable quantities of grapes are imported into this country. In 1905 we imported 700,050 cwt. of grapes, valued at £761,632. Of these, 664,383 cwt. were from foreign countries, chiefly Spain, which sent 543,807 cwt.

From British possessions came 35,667 cwt., Channel Isles 33,863 cwt., Cape Colony 1,645 cwt.

RAISINS are the dried fruits of a peculiar variety of *V. vinifera*, cultivated in Greece. Sultanas are the dried fruits of a seedless variety of this same species, also largely cultivated in Greece. The Black Corinth or Zante grape, a variety of *V. vinifera*, supposed to have originated near Corinth, and very widely cultivated in the Greek Archipelago, furnishes the dried currants of commerce.



TRINIDAD. THE CASHEW FRUIT

DATES are the fruits of the date palm (*Phœnix dactylifera*). This palm is a native of the dry, hot regions of Northern Africa: it is also cultivated there in immense quantities, and more sparingly in Western Asia and Southern Europe. In the dry parts of Northern Africa it is the principal food of a large proportion of the inhabitants, and likewise of the various domestic animals—dogs, horses, and camels being alike partial to it.

The FIG (*Ficus Carica*) is a deciduous tree, growing fifteen to twenty-five feet high in favourable climates: native probably of Asia Minor, but now very widely cultivated. The fig is hardy in the more favoured parts of the United Kingdom, and when grown against sunny walls or under glass fruits readily. Figs grown in this country are seedless, and are usually eaten in a green state.

Figs when fresh are pear or urn-shaped. Drying is effected in a warm climate by exposure to the sun's rays. In drying some of the grape sugar exudes and forms a white powder. These dried figs are packed in boxes under pressure, and constitute the figs of commerce. The figs imported into this country mostly come from the Mediterranean region, notably Turkey and Minor.

The PINEAPPLE (*Ananas sativus*) is universally acknowledged to be one of the most

delicious fruits in existence. A native of Brazil, it is now cultivated in the tropics of both old and new worlds. Its cultivation is also successfully carried on in hot-houses in this country, and, strange as it may seem, English-grown pineapples surpass in size and flavour those grown in the tropics. Large quantities of pineapples are imported into this country chiefly from the Bahamas and other West Indian islands.

MANGO (*Mangifera indica*), a medium-sized tree with large egg-shaped fruit, a native of India and now cultivated throughout the tropics of the world. There are many varieties of Mango, differing in size, shape, and flavour. The better kinds are esteemed among the finest of tropical fruits; the inferior ones are practically inedible. The unripe fruits are much used in India in conserves and tarts, and in the making of chutney.

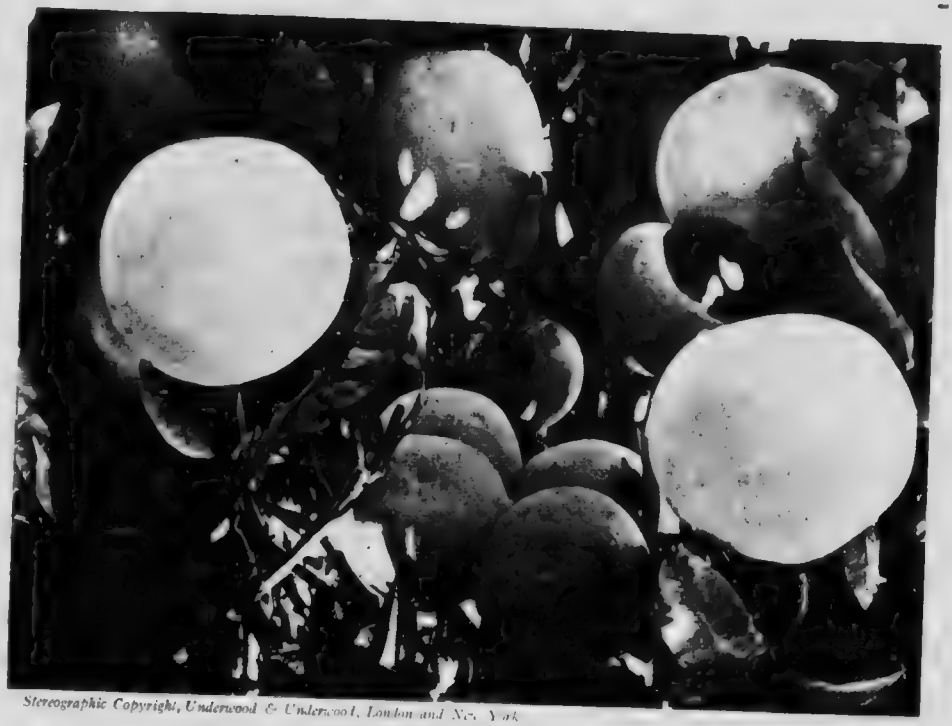
OLIVES. Pickling olives are the unripe fruits of *Olea europaea*, deprived of a portion of their bitterness by soaking in water to which lime and wood ashes are sometimes added, and then bottled in salt and water flavoured with aromatics. The olive is a small-growing evergreen tree, native, in all probability, of parts of Southern Europe and Asia Minor and cultivated largely on the shores of the Mediterranean; also in California, Australia, and other parts of the world. It is chiefly grown for its excellent oil. The tree is very slow growing and lives to a great age.



By permission of Messrs. Duperly & Son, Kingston, Jamaica

JAMAICA. BANANA HIGGLERS

The POMEGRANATE (*Punica Granatum*), native of Upper India, and possibly Northern Africa and Western Asia, is usually a large bush or small tree, fifteen to twenty-five feet high, with scarlet flowers and large globular fruits. Pomegranates are greatly valued in warm countries on account of their delicious cooling and refreshing pulp.



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CALIFORNIA. THE SHADDOCK GRAPE FRUIT

The Soursop (*Anona muricata*), Cherimoyer (*A. Cherimolia*), Sweet-sop or Custard Apple (*A. squamosa*), and Bullock's Heart (*A. reticulata*) are all small trees or shrubs, natives of South America, and now cultivated for their fruits in the West and East Indies, and other tropical countries. The fruits of all are large, with white or yellowish pulp, very juicy, with pleasant acid taste. The quality of these fruits varies in different lands, some being more appreciated than others. (See illustrations on p. 70 and p. 266.)

Avocado Pear (*Persa gratissima*) is a common tree in tropical America and the West Indies, where it attains the height of from twenty-five to thirty feet. The flesh surrounding the stone is yellow and green, soft, and buttery, with a delicious flavour. The fruits are usually eaten raw with pepper and salt, or lime juice.

The Papaw (*Carica Papaya*) is native of South America, but is now cosmopolitan in the tropics. The tree is of rapid growth and will thrive in almost any soil. The flavour is similar to that of a melon and the fruit is most wholesome.

The Guava (*Psidium Guaiava*) and the Purple Guava (*P. cattleyanum*) are well-known tropical fruits. Both are natives of the West Indies and tropical America. They are eaten raw and make very good jelly or preserve.

Litchis, occasionally sold in shops in this country, are the dried fruits of *Nephelium Litchi*, a tree wild and cultivated in the warmer parts of China, and in Cochin China and Malaya. When fresh the fruits are very luscious. They are also canned and exported from Hongkong.

Almonds. The Almond tree (*Prunus Amygdalus*) grows to the height of about twenty feet, and has leaves similar to the peach, but larger flowers. A native of Persia, Asia Minor, Syria, and Algeria, it is now widely spread in the warm temperate parts of the Old World. It is largely cultivated in the Mediterranean region, notably Spain, Italy, and Morocco, for the kernels of its seeds, which constitute the almonds of commerce.



PAPAW

Sweet Chestnuts are the fruits of *Castanea sativa*, a large tree closely allied to the oak, a native of Asia Minor and other parts of Asia, and now very widely cultivated. The nuts are highly nutritious. We obtain the bulk of our supplies from Spain, and although the Sweet Chestnut ripens its fruit in this country they are small and of little value.

Coco-nuts, the fruits of the well-known coco-nut palm (*Cocos nucifera*) now widely spread in the maritime regions of the tropics. Elsewhere in this work the coco-nut is dealt with at length. In parts of the Malay Archipelago coco-nuts are the staple food of the inhabitants.

Hazel Nuts (*Corylus Avellana*) are abundant in the hedgerows and coppices in parts of this country and on the continent. They are also cultivated, and the filbert and cob-nut are varieties which have originated under cultivation.

Brazil Nuts are the products of *Bertholletia excelsa*, a very large tree, native to the forests of South America. The nuts are principally exported from the port of Para in Brazil.

Walnuts of commerce are the fruits of *Juglans regia* denuded of their pulp. The tree is a native of Persia, temperate Himalaya, and China, and has been cultivated in temperate Europe from great antiquity. *Juglans cinerea* yields the Butter Nut of North America.

The Hickory Nuts (*Carya alba* and *C. nigra*) are closely allied to the walnut, and largely eaten in North America. The Pea Nut (*Carya glabra*) and Pecan Nut (*C. olivæformis*) are also natives of North America.

Ground Nuts, the fruits of *Arachis hypogoea*, are largely eaten as dessert in America, China, and elsewhere.

Cashew Nuts are the fruits of *Anacardium occidentale*, native to tropical America and the West Indies. The actual nut is the small body borne at the apex of the swollen coloured fruit stalk (see illustration on p. 275). They are very delicious when roasted, but as yet are but little known in this country.

RUBBER

Rubber, india-rubber, or caoutchouc, is obtained from the milky juice or latex of various plants, mainly found in tropical countries. There are in the United Kingdom many latex yielding plants, such as the common wayside milkweeds or spurges, poppies, periwinkles, etc., but they are not commercial sources of rubber. The actual rubber is a mixture of chemical bodies known as hydrocarbons, resins, water, and various other substances, varying with the kind of rubber, *i.e.*, which plant it is obtained from, the method of preparation, purity, and so on.

Commercial rubbers are distinguished by names denoting often the country of origin, such as Para rubber, Ceara rubber, Lagos silk rubber, etc. We will now proceed to give a brief account of the plants, and the method of cultivation and preparation of each of the chief kinds of rubber :—



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GROUP OF YOUNG HEVEA BRASILIENSIS TREES



By permission of Messrs. Maclaren, Shoe Lane

RUBBER TREES TWENTY YEARS OLD

PARA RUBBER

In tropical South America, in the basin of the Amazon and of the Orinoco, occur a number of trees of the genus *Hevea*, belonging to the Spurge Order (*Euphorbiaceae*), which yield rubber. The best known is *Hevea brasiliensis*, which is usually looked upon as the source of Para rubber, so called from the town of this name near one of the mouths of the Amazon, whence much of the rubber from Brazil is exported. Comparatively little is known with certainty as to the trees contributing to the rubber shipped from Brazil, but this is not altogether to be wondered at when we recollect that the rubber region embraces an area about two-thirds that of Europe; that the trees occur wild in dense forests and their produce is collected by natives and brought down for sale. Several species of *Hevea* are recorded as rubber producers in different districts, and members of other genera also contribute, but *Hevea brasiliensis* is, at any rate, one of the most important, and this is the tree which has been introduced with great success into other regions of the world, and is the source of the important and rapidly developing Para rubber industries of Ceylon and British Malaya, so that it is generally spoken of as the Para Rubber Tree.

Hevea brasiliensis thrives in the hot, damp forests of the Amazon valley, in what are known as the "islands" in the delta of the river, and also in the higher lands lying back from the valley of the river. The climate of this region is extraordinarily uniform, the annual mean temperature being about 80° F., and the daily range usually between 75° and 90°. The annual rainfall is from 80 to 120 inches.

The general habit of the Para rubber tree will readily be seen from the various illustrations. It attains a height of over sixty feet and a girth of eight to ten feet. The leaves are characteristically three lobed, the flowers are individually small and inconspicuous, but are borne

in little sprays, and are succeeded by dry fruits each containing three seeds about the size of large Kentish cob nuts, and with the curious brown and black mottling so characteristic of seeds of many plants of this family, e.g., the castor oil bean. The seeds are very oily and soon lose their vitality, so that special precautions have to be taken to transport them successfully over long distances when required for propagation.

COLLECTION OF WILD RUBBER

In Brazil, the trees are tapped during the dry season which varies in different districts. The rubber collectors or *seringueiros* search the forests for suitable trees which should not be less than about two feet in girth. An incision is made in the bark with an axe or cutlass and a receptacle fastened immediately beneath. The latex begins to run at once and is caught. A number of cuts are made in each tree, a cup fastened under each, and allowed to remain for a few hours. At the end of this time the flow of latex has ceased and the contents of all the little cups transferred to a larger vessel. The next step is to convert the still liquid latex into solid rubber. A fire is lighted and nuts of various species of palms placed on it. These produce a dense smoke containing acetic acid and creosote, which rapidly coagulates any latex exposed to it. A kind of paddle is dipped in the latex and held in the smoke. The rubber coagulates, forming a thin layer on the paddle. This is then dipped into the latex and again smoked. Another layer is deposited on the first, and the process is continued until a sufficiently large mass of solid rubber has been collected on the paddle. It is then removed and is ready for sale and export.



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TAPPING ACCORDING TO THE "DIRECT OBLIQUE" METHOD

PLANTATION OF PARA RUBBER

It will be convenient to present under this heading a *résumé*



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CASTILLOA ELASTICA

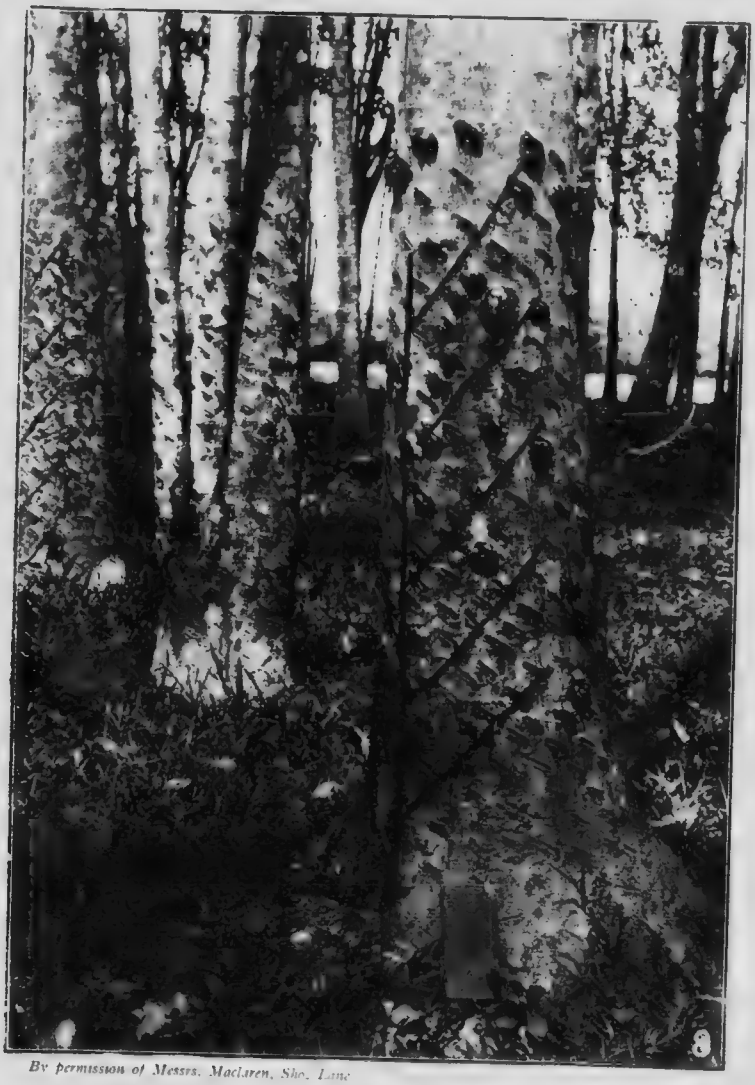
of the steps taken to establish the Para rubber tree as a cultivated plant in various parts of the world, with special reference to Ceylon and British Malava, in which the most important results have been attained. In 1876 Ceylon received from the Royal Botanic Gardens, Kew, some 2,000 seedlings of this valuable plant. The seeds had been collected in Brazil by Mr. H. A. Wickham, forwarded to Kew, and despatched thence to Ceylon in Wardian cases. A Wardian case, it may be said, is essentially a small portable glass-roofed box, in which plants are placed with a supply of soil and moisture so that they can be sent long journeys without injury. This is of particular importance to the plant. The cost of the experiment was borne by the Indian Government, but Ceylon was selected as having a more suitable climate, and the young seedlings were mostly planted out in a special garden at Heneratgoda, in the hot and moist region of the island. As early as 1897-8 young plants, raised from cuttings, were distributed to Madras, British Burma, and the Straits Settlements, and after the first flowering in 1881, when seedlings became available, the work of distribution was continued, and Australia, Fiji, the West Indies, Seychelles, and the west coast of Africa are amongst the widely separated places into which Para rubber plants have been introduced. The use of Wardian cases is the most satisfactory manner of transport over long distances, the seeds germinating *en route*, but very successful results have been attained with carefully dried fresh seeds packed in tins in dry powdered charcoal and coco-nut fibre dust or sawdust.

It was at first thought that the plant would only grow on moist, preferably periodically inundated ground, and near the sea level. This, however, has proved not to be the case, and good results have been attained in Ceylon up to an elevation of 2,000 feet, and in some cases even higher. The other requirements are practically those indicated as existing in the Amazon valley, *i.e.*, a rainfall of about 100 inches per annum, and a mean annual temperature of about 80° F. The plant grows very rapidly from seeds, the seedlings being raised in nurseries. The distance the plants are set apart depends on various causes, but if ten feet by fifteen feet is adopted the result will be 290 trees to the acre. If eighteen feet by eighteen



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FICUS ELASTICA AND ITS AERIAL ROOTS



By permission of Messrs. Maclaren, Sho. Lane

OLD TREES WHICH HAVE BEEN TAPPED BY THE SINGLE-INCISION METHOD

feet is adopted we get 135 trees to the acre, whereas twenty feet by twenty feet reduces the number to 109. In some cases it is advisable to plant comparatively closely, and tap the trees until they become crowded, and then by removing the worst give the others room for further development.

During the first four years, catch crops such as ground nuts, cassava, bananas, cotton, etc., can be grown. Sometimes the rubber plants are set amongst matured coffee (see p. 187) or tea, with the idea of removing the coffee or tea altogether later on, *i.e.*, gradually transforming a tea or coffee estate into a rubber estate.

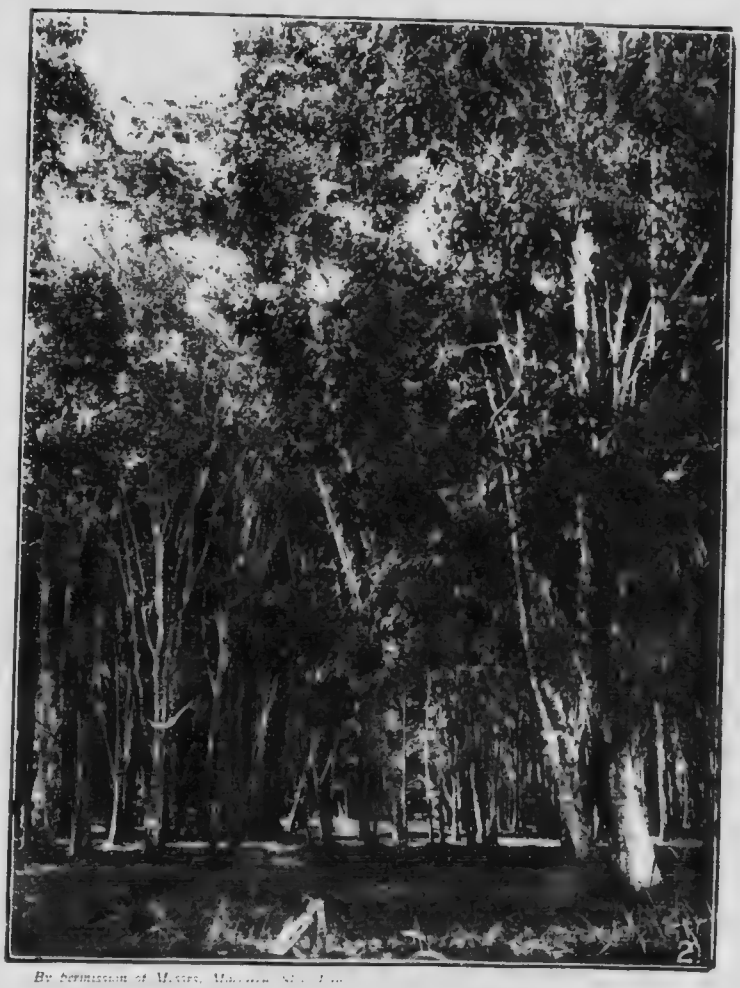
Tapping. Under good conditions Para rubber trees are ready for tapping when about five years old. The old method in Ceylon was to make V-shaped incisions in the tree, after the bark had been carefully cleaned, and to catch the latex which ran out in pieces of coco-nut shells placed on the ground, matters being so arranged that the latex from several cuts formed one stream, so that about three shells caught all t' produce of a medium-sized tree. The latex was allowed to remain in the shells, where it rapidly coagulated and was later removed. Some of the latex coagulated before it reached the cups, in narrow strips which were peeled off the trunk and wound up into balls of "scrap rubber."

As the result of careful experiments in Ceylon by Dr. J. C. Willis, the present Director of the Ceylon Botanic Gardens, and Mr. Parkin, an improved method was devised. The latex from each V-shaped cut was collected in a separate tin cup containing a little water, to keep the latex liquid for a while. The diluted latex was strained and poured into shallow dishes, a small quantity of acetic acid and creosote being usually added to assist the process of coagulation.

Here it coagulated, and as a result a cake or "biscuit" of rubber about ¼ in. thick was obtained, which was thoroughly dried by rolling and other means. (See illustration on p. 290.) These experiments resulted in putting on the market the now well-known "Para biscuits," which have earned a high reputation for their purity. They entail, however, a large amount of hand labour, and are accordingly being replaced at the present time by other and more expeditious methods. Before we refer to those it will be convenient to note that much experimental work has been and is being done in methods of tapping. The little cups, each under a separate cut, also demand a lot of labour, and it is found advantageous to collect the latex in as few cups as possible, some going so far as to suggest catching the yield of more than one tree in a single receptacle by means of suitable guiding channels. The "herring-bone" method is now largely adopted. It consists of a vertical cut several feet long, with branch cuts leaving it at an angle of about 45° alternately on either side. The branch cuts point upwards, and the latex from them runs into the central vertical cut at the lower end of which the cup is placed. In the half herring-bone branch cuts are made only on one side of the vertical cut.

Still more recent is the spiral mode of tapping. A series of cuts running spirally half-way round the tree is made from a height of six feet or so to the base. This method appears to be very successful. It has the advantage that as the wounds in the bark heal, the old places can be readily tapped again, and in the Para rubber the yield from over the same area increases rapidly at successive tappings, an interesting and important phenomenon spoken of generally as "wound-response."

The yields from some of the spiral tappings in Ceylon have been very high, as much as 25 lb. of rubber from a single tree in a year, without the tree showing any ill effects. Such a yield is, no doubt, exceptional, but for trees between five and ten years old, grown under



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GROUP OF HEVEA BRASILIENSIS



By permission of Messrs. Maclaren, Shoe Lane

MALAY PENINSULA. FICUS ELASTICA

good conditions and carefully treated, an average yield of 1 lb. to 3 lb. of dry rubber may be expected.

In the old days tapping was accomplished somewhat crudely with a chisel and a mallet. Now there are many patterns of tapping knives and "prickers" on the market, designed to carry out different styles of tapping in the best possible manner, and with the least injury to the tree. Particulars of these will be found in the work on "*Hevea brasiliensis or Para Rubber*," by H. Wright, Controller of the Experiment Station, Ceylon, which affords a comprehensive summary of information relating to the rubber industry in that colony. Even the shavings obtained in the tapping operation need not be wasted, but their rubber contents can be extracted.

Sheet Rubber. This is prepared in the same way as biscuit rubber, but in rectangular instead of circular receptacles. There are certain difficulties in handling and transporting these thin sheets, and recently a plan has been devised of pressing sheets or biscuits into blocks with satisfactory results.

Crêpe Rubber is another modern commercial form of plantation rubber. The latex is coagulated "in bulk" instead of in separate small receptacles. A large irregular mass of rubber is obtained which is passed through a washing machine and obtained finally in long thin ribands, perforated with small holes, and roughly resembling crêpe in texture.

Worm Rubber is also coagulated in bulk, pressed into thin sheets, which are cut up by large shears into irregular more or less worm-like pieces.

Lace Rubber is very similar to crepe rubber. All these last three forms can be made very expeditiously by the aid of machinery and have the great advantage of drying much more rapidly than the solid sheets or biscuits.

Plantation Para rubber is in an active experimental stage, and producer and buyer are co-operating to find the most advantageous method of preparation. A step towards this end was the important rubber exhibition held in Ceylon in 1906.

CENTRAL AMERICAN, CASTILLOA, OR PANAMA RUBBER

Central American rubber is one of the generally accepted names for the produce of *Castilloa elastica*, a large tree of the Nettle Order (*Urticaceae*), occurring wild in Mexico, Guatemala, Costa Rica, Honduras, Nicaragua, and on the western side of the Andes as far south as Peru and Bolivia. The plant has been known to science longer than any of the other rubber-yielding plants, and was first described by Cervantes at a meeting of the Royal Botanic Garden of Mexico in July, 1794, and copies of his original published description, with a figure of the foliage and flowers of the plant, are still in existence, although now very rare. The rubber



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FICUS ELASTICA; SHOWING ROOTS FEEDING ON DEAD WOOD



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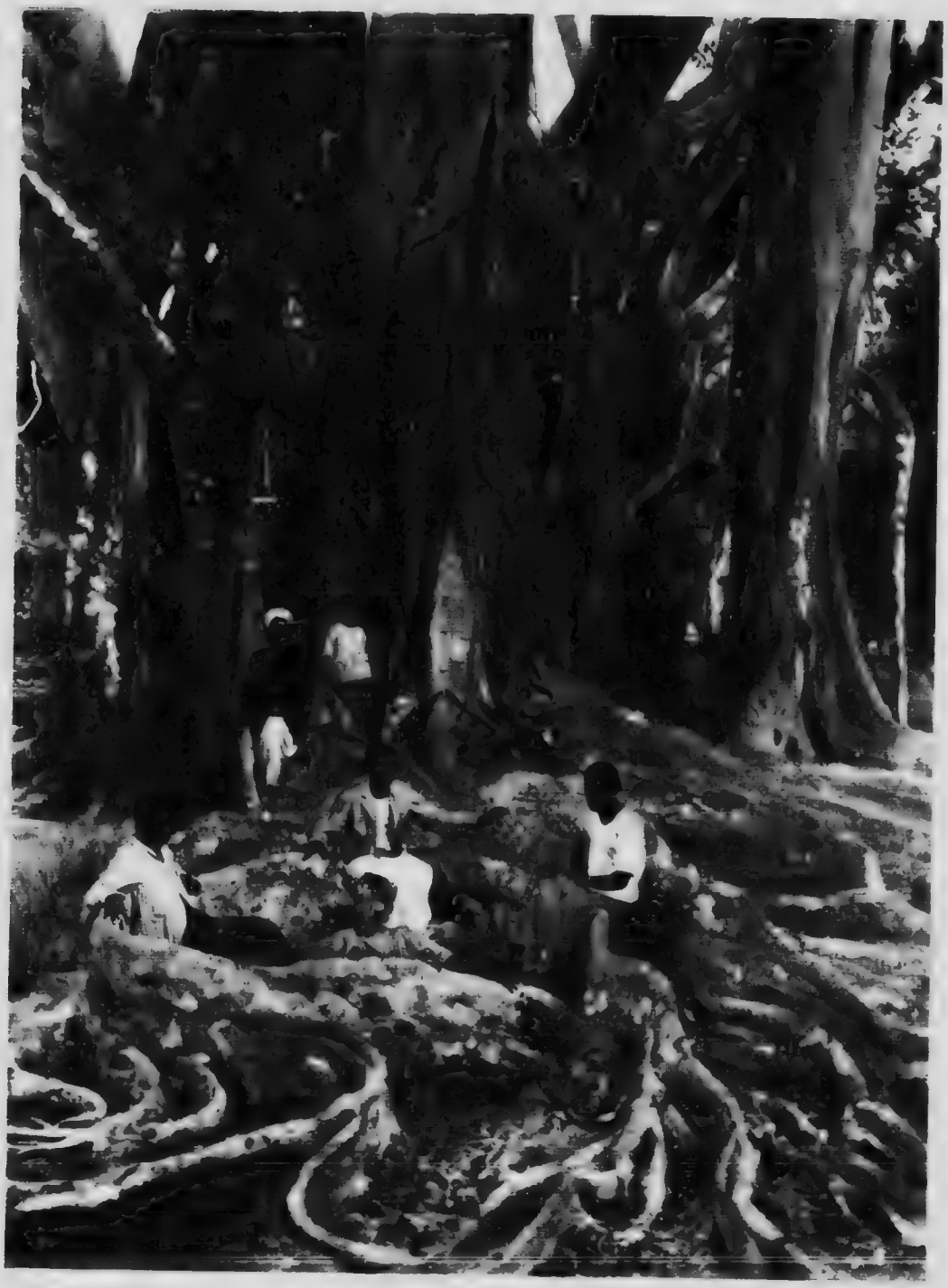
NEAR VIEW OF HEVEA BRASILIENSIS

passes commercially under a great variety of names, mainly denoting the country from which it has been obtained. The tree is also known under different local names; the Spanish name is Hule or Ule; the native Aztecs called it Olquaquitl; other names which have been applied to the plant are Caucho and Tunu. Although we have referred to this rubber as being obtained from one species of plant, there is considerable doubt as to whether this is strictly accurate, and Koschny, who has devoted great attention to the tree in Costa Rica, distinguishes and gives separate names to four distinct kinds or varieties, three of which yield rubber whilst the latex of the other forms only a resinous, brittle mass of no value. It is convenient to include all these varieties under the general name of *Castilloa clastica*, bearing in mind that we may be dealing with several closely related plants, rather than with only one species.

The Central American rubber tree is found in the forests in its native country, but it does not follow from this that it should be grown in forests or under the shade of other trees, when efforts are made to cultivate it. One reason for its only occurring in forests appears to be that its seeds are very thin-walled, and are rapidly killed if left exposed on open ground under the fierce heat of the tropical sun. When artificially sown, cared for, and shaded in its early stages, the plant has been found in other countries to grow more quickly, and to give better results in the open than in the shade. Similar instances are not uncommon in the plant world. It develops into a very large tree, sometimes more than 150 feet in height, with a rather smooth, light grey bark, and easily recognised in the young state amongst other trees by its peculiar branches bearing on either side a row of large leaves, generally about one to one and a half feet long (see Fig. on p. 282). These branches fall off later, and are succeeded by others of less characteristic form.

The plant appears to thrive best in deep, loamy soil, near the banks of streams, and in valleys, but it does not like swampy or boggy land. Like most of the rubber trees, it cannot be grown with success in places where the temperature falls below about 60° F. at any season of the year. A continuously humid climate is not necessary, and so far as observations go the yield of rubber is greater from trees growing in regions where wet and dry seasons alternate.

In the past the rubber was principally collected from wild trees, and as has happened in other parts of the world with other kinds of rubber-yielding plants, this led to the destruction, and in places almost complete extermination, of the plant. When the plants are wild the



Courtesy Miss Seil

CURIOUS ROOTS AND TRUNK OF THE INDIA RUBBER TREE

greed of collectors urges them ruthlessly to cut down trees to extract all the rubber possible rather than to tap the trees in a proper manner and conserve the supplies. The increasing scarcity of rubber in accessible regions has led to efforts being made to cultivate *Castilloa* as well as other kinds, and very large plantations are now established in Central America. The plant, largely through the instrumentality of the Royal Botanic Gardens, Kew, has been distributed to many parts of the British Empire including India, Ceylon, the Straits Settlements, the West Indies, Queensland, etc. In Tobago, the dependency of Trinidad, it is cultivated on a commercial scale with successful results, and it has given considerable promise of being suited to other West Indian islands. In the East Indies it is at present overshadowed and put into a secondary position owing to the success which has attended the cultivation of Para rubber, to which the energies of the rubber planters are now almost entirely devoted.

It has been suggested that *Castilloa* would form a good tree to plant where shade is wanted for cacao, coffee, and other crops, in the place of other trees commonly so used, but which yield no useful crop. This has been done to some extent in Central America and Tobago. In some instances successful results are reported, in others the contrary, and it is difficult to lay down any hard and fast rule as to whether the practice is to be commended or not.

Like other rubber-yielding plants, a good many years have to elapse before trees are ready to be tapped. The actual age varies in different countries, and in the same locality, with trees under varying conditions, but as a general rule it is safe to say that about eight to ten years is the average age at which tapping should be commenced. Younger trees do not yield good rubber, but a sticky material containing a high proportion of resin and of very low commercial value.

The worst method of collecting the rubber is to cut down the whole tree, make deep cuts in its bark, and extract every drop of latex or milk which can be obtained. This is too frequently done where the trees are



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"THE REVERSED OBLIQUE" SYSTEM

wild and there is no check on the greed of collectors. The result is, of course, rapidly exterminate the trees over any region, and, although high yields are obtained for a while, t supply is soon exhausted. It is the old story of killing the goose which laid the gold eggs, and the result is equally disastrous. Whenever possible this reckless waste is prevent and more rational methods insisted on.

In Nicaragua the following method is adopted as described by Belt in his interesting bo of travels in that country. The collect having found a tree, construct a rou hanging ladder from the climbing pla common in the jungle, and with the aid this make, with a cutlass or large kni V-shaped incisions in the bark, the poin of each V being downwards. The "milk runs out of the cuts and trickles down t trunk to the foot, where it is collected vessels. A watery decoction obtained fro the stems of a wild convolvulus is added t the rubber milk and the mixture stirre when the rubber coagulates and forn masses which float on the surface. The are taken out and kneaded into flat, rou cakes, which are afterwards exported. H states that a large tree, five feet in diamete yields, when first tapped, twenty gallons milk, and each gallon gives 2½ lbs. of rubbe



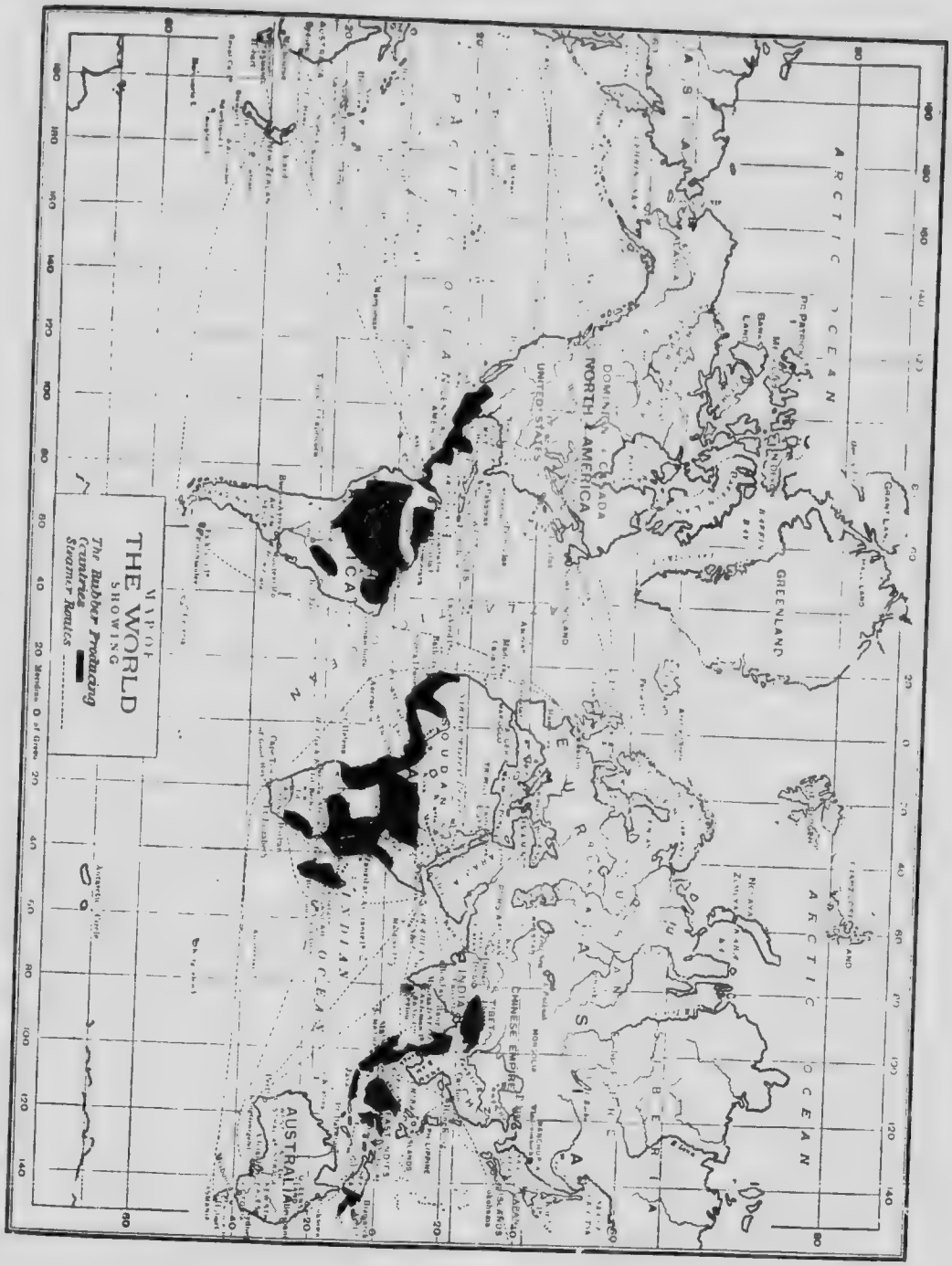
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FICUS ELASTICA WITH V-SHAPED CUTS

Sometimes a continuous spiral cut made up the trunk down which the ju runs. Other modes are also adopted, bu the general result is the same. The meth of coagulation also varies. Thus the lat may be boiled, or spread out in thin lay on large leaves and exposed to the air, alum may be added, the latex of *Castil* not usually coagulating readily by itself.

ASSAM RUBBER

Few plants are of greater interest to on first visiting the Eastern tropics than th Assam rubber tree, familiar to everyon from the small plants so commonly grow indoors in Great Britain and known a "Rubber plants." In its native haunts i place of a pot plant we see a tree, as tall as a large elm, with a confused and intricate networ of curious buttress roots spreading over the ground in all directions, and often apparentl several trunks. The latter peculiarity is due to the fact that this tree, like many othe members of the fig tribe, has the power of putting down from the branches slender root These, arising from a branch perhaps thirty or forty feet high, descend to the ground, lookin like pieces of smooth twine; on reaching the ground they penetrate it, tighten up, grow ver rapidly in thickness, often equalling, or even exceeding, the original trunk. As several of the aerial roots may be formed and take root, one tree may have at a later stage in its growt apparently several trunks. Like many of the tropical "Figs," it frequently begins its life a


MAP OF
THE WORLD
SHOWING
The Rubber Producing
Countries
Steamer Routes
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ARCTIC OCEAN
NORTH AMERICA
SOUTH AMERICA
EUROPE
ASIA
AFRICA
AUSTRALIA
GREENLAND
CANADA
UNITED STATES
BRAZIL
PERU
BOLIVIA
SOUDAN
INDIA
CHINESE EMPIRE
TIBET
MONGOLIA
SIBERIA
BORNEO
SUMATRA
JAVA
CEYLON
NEW ZEALAND



ROLLING RUBBER

seedling high up on another tree, the seeds having been deposited by a bird in a hollow or in a fork. The young plant puts down its aerial roots, gradually enveloping and finally killing the supporting tree. The botanical name of the plant is *Ficus elastica*. It is a very close relation of the edible fig, but its fruits are small and are not good to eat. The large leaves as seen in plants grown in England are also characteristic of young plants growing wild; on old trees the leaves are only three or four inches long, but of the same leathery character and equally glossy.

The Assam rubber tree will grow in many tropical and sub-tropical lands, but to attain its full development it requires a hot climate with a high rainfall, and thrives best in damp tropical forests. The home of the Assam rubber tree is on the lower slopes of the great mountain ranges of northern India, in Darjeeling, Sikkim, Bhotan, Assam, and Burma. It also occurs in Java, Sumatra, and probably some of the other islands of the Malayan Archipelago. In the north of India the temperature in the coldest season of the year is too low to allow of the successful cultivation of the Para or Central American rubber trees, and experiments with those plants have not met with success. Large plantations have, however, been formed by the Indian Government in Assam with *Ficus elastica*, and from those of the wild plants in the forests of this region much of the rubber obtained from India is won. It is worthy of note that the common name "india-rubber" commemorates the first production of rubber from tree in the early years of the nineteenth century.

The native method of collecting the rubber is exceedingly crude and, moreover, is destructive. Large wounds are made in the trunks by chopping out great pieces of the bark and wood, and the latex is caught as it exudes. By this method many trees are permanently injured, but, as is often the case in other parts of the world also when dealing with wild plants, each collector only strives to obtain the greatest amount of rubber in the easiest way, and takes no thought for the future, so that trees are often killed.

A method practised in the Government plantations is to make cuts with a V-shaped chisel or gauge halfway round the stem or branch. The latex or milk at first flows freely and that which drips is collected on mats made of bamboo strips, which little boys shift about on the ground from point to point as necessary. This latex coagulates, and within forty-eight hours or less can be removed from the mat and dried. Much of the latex coagulates on the tree and remains in the cuts whence it has to be pulled out as thick elastic strings. These have to be gone over and pieces of bark, etc., removed, and subsequently dried. Finally they are forced, by the agency of a screw-press, into cubes of about 1 cwt. each, wrapped up, and are then ready to be exported. The mat rubber is similarly cleaned, dried, and packed in boxes.

The returns of the yield of rubber are very variable. Under the method of reckless tapping 40 lb. per tree was frequently obtained, whilst yields of over 350 lb. of rubber from single trees are reported from Burma. On plantations the yields appear small. In Assam on the

Government plantation in some years it has been less than 8 oz. per tree, whilst sometimes rising to about 2 lb.; individual trees have [illegible] 20-30 lb. A recent estimate of Mr. Gustav Mann, of the Indian Forest Department, places fifty years as the time for the tree to reach maturity, from when onward they would probably yield 10 lb. of rubber at each tapping.

LAGOS SILK RUBBER

Lagos silk rubber is obtained from *Funtumia elastica*, a medium-sized tree found wild on the tropical Africa. It will often be found referred to as *Kickxia africana*, but the true kickxias are all Malayan, whilst the *Funtumias* are African plants. The tree occurs in Liberia, the Gold Coast, Lagos, and Southern Nigeria, the Cameroons, and the Congo. There is some reason to believe that it is present also in Sierra Leone, but this is not quite certain. Until quite recently it was thought to be entirely confined to the West coast of Africa, but Mr. M. J. Dawe, in the course of his botanical exploration of the Mabira Forest, Uganda, found it there also, an important discovery materially altering our ideas of its geographical range.

Funtumia belongs to the same natural order as the Landolphias, and, like them, is related to our common garden Periwinkle. Its flowers are white or yellow, and the seeds are very characteristic, each bearing a beautiful silky plume about two inches long, by means of which they can float through the air like thistledown, and may often be found travelling about through "West Coast" forests.

The trees are tapped by making incisions in the bark, the herring-bone system described on p. 285 being often adopted. A native climbs the tree making the vertical cut as he ascends, and the side cuts leading into it as he descends. The latex runs out and is caught in a calabash, earthenware pot, or other receptacle. It is coagulated either naturally, by application of heat, or by admixture with other latices or juices of various plants. The coagulation of pure Funtumia latex is very slow, but heat and the other methods make the process much more



Photo by W. H. Jones, Esq., F.L.S.

ANCIENT PARA TREE, EAST CEYLON



By permission of Messrs. Maclaren & Co., Shoe Lane.

TREE RECOVERING AFTER TAPPING

tapped. The rubber is of good quality, and comes on the market in "lumps" and in other forms. The collection and exportation of this rubber, now so important an industry in many parts of the west coast, is quite a modern development. As noted in the Colonial Report on Lagos for 1905, "Merchants took up the idea with enthusiasm. With startling suddenness the easy-going native awoke to the fact that wealth abounded in the forest round him and learnt for the first time that in sitting under his own fig tree he had been unconsciously reposing in the shade of the family bank."

The cultivation of this rubber tree is being undertaken in West Africa, and it has also been introduced into other parts of the world, growing, for instance, very well in parts of the West Indies.

CEÃRA RUBBER, OR MANICOBA

Ceãra rubber is obtained from a tree of medium size known botanically as *Manihot Glaziovii*, belonging to the Spurge Order (*Euphorbiaceae*). It is a very close relation of the cassava plant (*M. utilissima*), from which tapioca, amongst other products is made. The cassava plant also has a milky juice but it does not yield rubber, and it is interesting to find two such closely related plants, one yielding a valuable foodstuff and the other rubber. A native of Brazil, the Ceãra rubber plant was brought into notice in 1876, when seeds and plants were collected in Brazil by Mr. Cross and transmitted to the Royal Botanic Gardens, Kew. In the following year plants were distributed from Kew to India, Ceylon, and other colonies. The plant has been introduced into many parts of the tropics, for, like most of the other rubber plants, it only thrives in hot countries, and now it is grown in such widely separated countries as India, Ceylon, Queensland, West Africa, Zanzibar, Uganda, Natal, the West Indies, as well as in its original home.

It grows with tremendous rapidity, plants raised from seed often reaching ten or more feet within one year and thirty feet by the end of the second year. Once seen, the trees are easily recognised by their spreading habit, their five-lobed, curiously bluish-grey leaves, and the bark, which peels off in thin sheets or strips, like that of a silver birch. The plant will thrive in places absolutely unsuited to most cultivated plants. Rocky and stony soils, of poor quality and in arid districts, present no obstacles to it, and although, setting aside Central America, but little is done with the plant at present, it is not improbable that in time it will be grown to a considerable extent on lands which are not suited to other rubber plants.

Trees raised from seed can be tapped when about four to six years old. The thin outer layer of bark are usually removed, and either the whole surface scraped sufficiently deep to allow the latex to escape, or incisions made here and there with a knife. The latex is very liquid

and flows readily. It coagulates on exposure to [illegible] of palm nuts, as described in the case of Para rubber.

In Ceylon, where the tree was planted [illegible] rubber were low, and little attention is [illegible] Ceylon was about 17,500 lb. in 1895 but two years [illegible] Large plantations, however, exist in Brazil, [illegible]

The Brazilian product is exported as (1) pale [illegible] and (3) smoked rubber prepared like Para rubber.

Ceara rubber is of good quality, although not so valuable [illegible]

LANDOLPHIA RUBBERS

The plants producing this group of rubbers are chiefly [illegible] in the forests of the warmer parts of Africa, often [illegible] dense, tangled masses of more or less rope-like stems. Many of them bear in profusion conspicuous jasmine-like flowers, often sweetly scented, and succeeded by large, frequently brightly coloured, and sometimes edible, fruits. They belong to the genus *Landolphia* of the natural order *Apocynaceae*. In Great Britain this order is represented by the pretty "Periwinkles" (*Vinca major* and *V. minor*), whose stems also yield a milky juice or latex, although not rich in rubber as is that of their African relatives. Owing to their habit of growth, the Landolphias are not very well suited to cultivation, although efforts made in this direction have met with some success.



"HALF HERRING-BONE" SYSTEM

There are many species of Landolphia, but they do not all yield good rubber, and we may restrict our attention to the more important.

The West Coast Species. In Senegal, Gambia, and Sierra Leone, that is, generally speaking, in the more northerly portion of West Africa, *Landolphia Heudelotii* is a most important source of rubber.

As we proceed farther south this species is replaced by *Landolphia ocariensis*, which is widely distributed on this side of the continent, ranging from about Sierra Leone right down to Angola. It is one of the principal rubber plants of French West Africa, the Gold Coast, Nigeria, the Congo, and Portuguese West Africa. In the Congo there also occurs *Landolphia Foreti* and other species. Another interesting form is *L. Henriquesiana*, a small shrubby plant springing from underground stems or rhizomes which when pounded, form one of the sources of "root rubber."

The East Coast Species. The principal rubber plant on this side of Africa is *Landolphia*



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FICUS ELASTICA, SHOWING TANGLED GROWTH

Kirkii, which ranges from German East Africa to Natal. Recently Mr. M. T. Dawe has added an important new species, which he found in Uganda, and has been named *L. Dawei* after him. It yields very good rubber. Interestingly enough it also occurs in the Cameroons, on the west coast. In Madagascar there are several species, of which *L. Madagascariensis*, *L. Perrieri*, and *L. sphaerocarpa* are the most important.

Collection. The natives make incisions in the stems of these plants, and catch and coagulate the latex in various ways. Sometimes it is allowed to run into receptacles, and either coagulates by itself, or is induced to do so by addition of a little lime juice, or other plant juices, or by heating. At other times the native smears the milky juice over his body, peeling it off when it has formed a film. Some also hardens on the plant and is pulled away. The mode in which the various Landolphia rubbers come on the market varies considerably.

If coagulated in bulk, it may be cut up into strips which are rolled up to form "twists" or "balls," or it may be exported in "lumps," in small pieces known as "thimbles," or in various other forms which we have not space to enumerate.

GUAYULE RUBBER

This rubber, which has recently come into notice, is obtained from a plant known as *Parthenium argentatum*, fairly closely related to the Sunflower of the *Compositae*, and is of interest as being the only plant in this large order known to produce rubber. Whereas the rubber plants already described are mainly trees or large woody climbers, this is a small herbaceous plant varying in height from a few inches to between three and four feet. It occurs principally in North Mexico on the "bush prairies," but extends also into the southern United States.

The rubber contained in this plant cannot be obtained by tapping, as in ordinary rubber

trees, but the whole plant has to be cut down and the rubber extracted either by the use of solvents or by mechanical methods. Very careful washing is essential, and the necessity for a large supply of water is one of the practical difficulties encountered. Factories have been erected, the largest being stated to be at Torreon, whilst there is another at Ocampo. The crude rubber contains a high percentage of resins, over twenty per cent., but these can partly be got rid of by proper treatment. The product is of very fair quality, although usually somewhat soft and sticky.

TIMBER

THE United Kingdom is largely dependent for its supply of timber on other countries, and the annual value of wood imported is about £25,000,000.

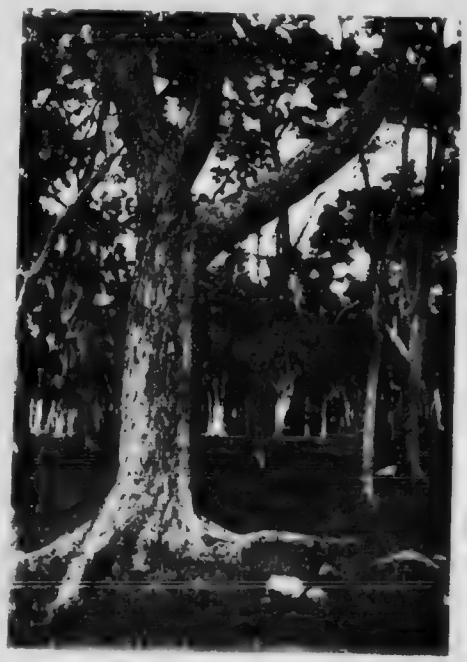
DEAL is a name applied to a number of timbers. It is important, however, to note that originally it was not the name of a timber at all, but rather of particular sizes of certain timbers. Thus, one of the most important of European timbers is Yellow Deal, the wood of the common Scotch Fir (*Pinus sylvestris*), so well known in the United Kingdom, and used more extensively for ordinary carpentry work than any other timber. Vast forests of this tree occur in Prussia, Prussian Poland, Russia, Norway, Sweden, etc. The best quality for certain purposes is exported from Dantzic, having been floated down the Vistula. At Dantzic the timber is carefully sorted into various grades. Whole trees varying from two feet to six feet in circumference at the base are known as "hand masts"; others less than two feet as "spars" and "poles," whilst those bigger than six feet are trimmed down and called "inch masts." From the remainder the best logs are carefully selected for conversion into "deals" about nine inches in width and three in thickness. Squared-up timber of eleven inches or more in width forms planks instead of "deals." Deals are in great demand by various Governments for the decks of men-of-war, and must be practically free from sapwood. Next come ordinary planks or boards for more general purposes in which absence of sapwood is not essential. The more irregular logs are made into railway sleepers.

Dantzic fir is coarse, large sticks being chiefly exported. Smaller or "milder" timbers come from Riga, Memel, whilst joiners' deals are mainly obtained from Christiania, Stockholm, Gefle, Soderham, and Onega. In the dry climate of Northern Europe fir is practically indestructible.

WHITE DEAL. White Deal is the wood of the common spruce (*Picea excelsa*), which occurs over northern and central Europe, forming great forests. It is found on the mountains in the more southern districts, but grows right down to the sea level in the north, *e.g.*, in Norway. Spruce is extensively planted in Great Britain, and there is a famous avenue of old trees known as the Cathedral Firs at Oakley Park, Cirencester. Burgundy pitch (*q.v.*) is obtained from this tree.

The timber is usually white or somewhat brown, and is distinguished from ordinary deal in having no smell. It is light, soft, elastic, straight and fine grain, and has innumerable uses.

The best white deals come from Christiania



A MAHOGANY TREE



By permission of the West Australian Agency

"CRIB TIME" IN THE BUSH

and Stockholm, and are very suitable for internal work. Inferior qualities are known as spruce deals.

WHITE PINE. The White Pine (*Pinus strobus*) has been for many years the most important timber tree of Northern America. It is well known in Great Britain, where it is frequently grown under the name of Weymouth Pine.

The White Pine occurs throughout a broad belt stretching across North America in the latitude of the Great Lakes. The destruction has naturally been very great in a tree which has been employed for endless purposes for the past two centuries, and careful attention to the maintenance of the supply for future generations is absolutely imperative.

White Pine may be taken as a typical example of the "soft pines," and as it is very easily worked, has a fine, even grain, and takes a good surface, it is very extensively used as a general timber for internal carpentering and joinery work, for ship masts, and for pattern-making.

PITCH PINE, LONG LEAF PINE (U.S.A.). In the markets of Europe, the West Indies, and other parts of the world to which this timber is exported, "pitch pine" is the generally recognised name, but in the United States, its native country, another tree altogether, *Pinus rigida*, is known as Pitch Pine, whilst "Long Leaf Pine" is a commonly accepted name for *P. palustris*.

Pitch Pine is particularly adapted to heavy construction work, *e.g.*, for bridges, building supports, railroad cars, railway sleepers, etc., etc. It is, however, apt to become "granular" under continuous cross strain. The annual output is enormous, for not only is the timber very largely used in the United States, but it is exported in constantly increasing amounts to Europe.

Central and South America, the West Indies. The wood is heavier and stronger than that of any other pine regularly on the market, and it is a good example of "Hard Pine."

Short Leaf Pine, Yellow Pine (*Pinus echinata*). This good timber tree occurs in the same region of the United States as the Long Leaf or Pitch Pine, to which it is but little inferior. It is likely in the future to be of more commercial importance than at present.

Sugar Pine (*P. Lambertiana*). Amongst the soft pines of North America mention should be made of the "Sugar Pine," which forms extensive forests in California and Oregon. It fills in the western portion of the United States the place occupied by White Pine in the east, and in California, for example, is extensively employed for doors sashes, as a building timber, and for general purposes.

Douglas Fir or Oregon Fir (*Pseudotsuga Douglasii*) is widely distributed in Canada, where in some places it forms immense forests, and is one of the chief trees of the western United States. Mexico is the southern limit of its distribution.

The tree grows very rapidly, and the timber is hard, firm, coarse-grained and heavy, and as it can be obtained in great lengths and widths of very uniform quality, is very valuable for heavy structural work, and is extensively used in ship-building, wharf construction, spars, masts, piles, etc., and also for furniture and many other purposes. The celebrated flagstaff, 159 feet high, in the Royal Botanic Gardens, Kew, obtained from a single tree in one piece, affords an excellent idea of the possibilities of the plant.

The timber would be classed as a hard pine, and does not resemble white or yellow pine. A good deal has been imported into this country of recent years, but it does not find favour for joinery.

Kauri Pine or Cowrie Pine (*Agathis australis*—Pine Order). This is the most important timber tree of New Zealand, and forms by far the greatest part of the wood exported from that



By permission of the New Zealand Government

OXEN HAULING KAURI LOGS



By permission of the Agent-General for British Columbia

A GIANT CEDAR TREE, STANLEY PARK, VANCOUVER

country, although the tree is only found in the Auckland district in the extreme north of North Island. It develops into a magnificent tree, with a smooth columnar trunk free from branches, bearing at the top a broad crown of foliage. Specimens are found 160 feet high, with a clean bole of 100 feet before the first branch is reached, and about fifty feet in circumference (see illustrations on pages 299, 301, 307, 310).

The value of the wood was early recognised in New Zealand, where it is extensively used. The first exports were to Australia, and later it won a place in the markets of the Old World. The great length and width of the planks obtainable, their remarkable soundness, uniformity, freedom from knots and faults, their durability and working qualities, make Kauri a most valuable wood for many purposes. For all kinds of building work, dados, panelling, doors, flooring, joiners' work, it is extensively used. A church at Peebles, in Scotland, and St. Michael's Church, Croydon, have fittings made of it.

Fine specimen planks, both of ordinary and of the handsome mottled Kauri, are exhibited in the New Zealand Court of the Imperial Institute. Kauri resin (*q.v.*) is obtained from this tree.

LARCH. The Larch (*Larix europea*), unlike most coniferous trees, drops its leaves during the winter, and the pale green of young Larch trees is very conspicuous in the spring. The tree is widely distributed over the Alps, the Apennines, in Russia, Siberia, etc., and yields a tough durable, somewhat coarse, but straight and even grained wood. Its most serious defect is that it shrinks and warps considerably. Ship-building, telegraph poles, sleepers, are amongst its principal uses. Venice turpentine (*q.v.*) is obtained from the Larch.

The American Larch or Tamarack (*Larix americana*) is very similar.

HEMLOCK. Two kinds of hemlock occur in North America. Western Hemlock (*Tsuga mertensiana*), yielding a strong, coarse timber, and the Eastern Hemlock (*Tsuga canadensis*), a smaller tree.

BIRCH. The common Birch, the most graceful of British trees, is our representative of a group found all over Northern Europe and America, and interesting as growing farther north and at higher elevations than any other trees in this region. The wood varies from white to various shades of pale yellow or red, is of fine, close, even grain, soft but very durable. Its uses include turnery, pit props, manufacture of barrels, ladders, *sabots*, etc. It is extensively employed at High Wycombe and elsewhere for the cheaper class of chairs, and choice pieces show a beautiful wavy figure, and are used as veneers for furniture-making.

The ALDER (*Alnus glutinosa*), usually found in damp places in Europe, North Africa, and the northern parts of Asia, gives a reddish yellow wood, very similar to birch in general character and uses. Like birch, it is extraordinarily durable under water, and is much used for piles, sluices, and pumps. Alternately wet and dry it rapidly decays.

WHITE WOOD. This timber is obtained from a large tree (*Liriodendron tulipifera*), which under the name "Tulip Tree," is not unfrequently grown in this country. The wood itself bears a great variety of names, as, for example, Canary wood, Canadian or American white wood, yellow poplar, etc.

The tree attains a large size, and the wood is white, canary yellow, or grey in colour, light, soft, pliable, and, of fine even grain. It seasons well, although shrinking considerably. In England it is generally used in joinery, but in its native countries, Canada and the United States, car and ship-building, house-finishing, panels of wagons and carriages, pump logs, furniture, and many other uses are made of it. To the carver white wood is exceptionally suited.

BASS WOOD is the timber of the American lime tree, also known as the "bee tree," American linden or lin. The tree grows to a height of eighty feet or so, and is found in Canada and all through the eastern United States.



By permission of the New Zealand Government

FELLING A KAURI TREE

The wood is light, soft, of fine, even grain, and white or light brown in colour. It is not very strong, and although fine grained, is very open, requiring considerable "filling" in polishing. Easily worked and lasting well, it has many uses for interior work, such as for furniture, turning, carving, toys, panelling in carriages, etc. Bass wood is well appreciated in this country, where, however, it is often confused with American white wood. It is imported in prepared boards of various thicknesses and widths.

White bass wood is obtained from another lime (*Tilia heterophylla*), a smaller tree than the preceding, and found on the Alleghanies.

Oak. There are a very large number of kinds of oak in commerce, but the true European oak is obtained from varieties of *Quercus Robur*, the ordinary oak tree of this country, and found generally over Europe and part of Asia. Several other species of Quercus yield oak in Europe and also in North America. The general character and uses of oak are very well known. For strength and durability it is most valuable. Oak suffers from one drawback: it rusts when in contact with iron (compare teak).



From Stereograph Copyright, Underwood & Underwood, London and New York

A SAW MILL IN THE BIG TREE DISTRICT, CALIFORNIA

Many other timbers have also been termed "oaks." For instance, African oak (*Oldfieldia africana*), a useful hard wood obtained from tropical Africa; Indian oak, another name for teak; She oak, applied to the woods of some of the Australian Casuarina trees, and so on.

Chestnut Wood is that of the Spanish or Sweet Chestnut (*Castanea vulgaris*), commonly grown in Great Britain as an ornamental tree or in coppices for the sake of the poles it yields. It should be distinguished from the Horse Chestnut, its fruit being the edible chestnut. The wood is fairly hard, of various shades of brown. Speaking generally, chestnut can be put to many of the same uses as oak, which it strikingly resembles in colour. The roof of Westminster Hall is said to be made of chestnut. The old wood is rather brittle, and where strength is essential, timber from very old trees should be avoided. In the South of England coppiced chestnut is grown for the sake of its young stems, which are used as hop poles, etc.

Elm. The elms occur throughout the north temperate zone, and two are abundant in Great Britain, the Common Elm (*Ulmus campestris*) and the Wych Elm (*Ulmus montana*). Elm wood is of moderate hardness, coarse grained, very strong and tough. It is usually cross grained, and so is very difficult to split. Water has very little effect on it, and elm is largely used for the keels and other submerged parts of ships, for piles, pumps, sluicing work, etc., and for coffins. The early water conduits were made of hollowed-out elm trunks, and some were in use in London until comparatively recently. Although so durable under water, it readily decays in situations where it is alternately wet and dry, and is thus of but little value



By permission of the Agent-General for British Columbia

A GIANT CEDAR TREE, STANLEY PARK, VANCOUVER

for work to be exposed to the weather. As an instance of its durability under water, it is recorded that the piles of old London Bridge were of elm, and they stood for about 600 years without showing much sign of decay. Naves and spokes of wheels, boards for carts, barrows and other vehicles of cheap construction are frequently made of elm.

In the West Indies an altogether different tree (*Cordia gerascanthus*) is called Spanish Elm; in commerce it is known as Prince Wood.

BEECH. The Beech rivals the oak as the largest British tree, and the Windsor Beeches and Burnham Beeches are of wide renown. The Common Beech (*Fagus sylvatica*), which occurs wild in England, is found also over a large part of Europe, generally forming extensive forests. Other members of the group occur in such widely separated countries as North America, Australia, and New Zealand, Tasmania, Java, and Tierra del Fuego. Beech wood is reddish-white



Photo by W. F. Edwards, Littlehampton

A LUMBER CAMP, BRITISH COLUMBIA

in colour, heavy, moderately hard, and very fine and close grained. Exposed to the weather it is not durable, although it is so under water, and is used for mills, sluices, piles, etc. It is largely employed for making chairs, general joinery, the bodies of planes, butchers' blocks and trays, wooden shoes or *sabots* on the Continent, and by wheelwrights and coachbuilders. Taking a "thread" well, it is used for wooden screws, and also for shoe lasts and trees. Beech burns slowly, is a good fuel, and makes excellent charcoal.

SYCAMORE. The ordinary sycamore tree (*Acer Pseudo-Platanus*), found in Europe and North America, yields a close, fine-grained, white wood, which is useful for general carpentry.

The PLANE (*Platanus occidentalis*), often called Sycamore in the United States, also affords a useful timber. Both sycamore and plane are sometimes called "button wood."

MAPLE. One maple, the common field maple, occurs wild in the United Kingdom, but is of no value as a timber tree. The maple wood of commerce comes from North America, the most important kinds being "hard maple" from the Sugar Maple (*Acer saccharum*), Red Maple

(*A. rubrum*), Silver Maple (*A. saccharinum*), and Broad-leafed Maple (*A. macrophyllum*). The first two are the more valuable. Maples also occur in Northern India and other parts of Asia. The Hard Maple, also known as Rock Maple, occurs in Canada and the United States, on the eastern side of the continent. The wood is well known in this country owing to its extensive use for furniture, decorative panelling, and is hard, tough, of fine texture, and of various shades of yellow and brown in colour. In addition to the uses with which it is popularly associated, it is extensively employed for flooring, the keels of boats and ships, the manufacture of machinery, turning shoe lasts, tool handles, and many other purposes. The figured variety, known from its peculiar marking as Bird's Eye Maple, is highly esteemed.

POPLAR. Various kinds of poplars occur throughout the Northern Hemisphere, and in the United Kingdom we are most familiar with the White and Black Poplars, and the Aspen, all well-known trees. They yield a wood which is light, very soft, of fine grain, and generally with a silky lustre. Poplar wood is not strong, but is easy to work. Cotton wood is the name in the United States for some of the members of this group.

Canary white wood markedly resembles poplar, and is often described as yellow poplar or Virginian poplar.

WALNUT. The ordinary walnut tree (*Juglans regia*) of this country occurs wild also in Europe generally and parts of Asia. Its dark-brown timber is often very beautifully marked and much appreciated for furniture, etc.; it is also used for gun-stocks.

American Walnut, or Black Walnut, is derived from a closely related tree (*Juglans nigra*), which is a native of the United States and Canada.

HOLLY. The hollies have a wide geographical range, occurring throughout most of Europe, Asia



Photo by N. P. Edwards, Littlehampton

FELLING A REDWOOD TREE

Minor, North and Sout America, and to a less extent in Africa and Australia. Thre different species yield commercially useful timber in Europe and North America. The hard, finely grained, close wood is well adapted for turning, and is used for this purpose, for the manufacture of cogs, and in cabinet and marquetry work.

Ash. There are some fifty or more kinds of ash trees, but only one is found wild in the United Kingdom, namely, the English Ash (*Fraxinus excelsior*), which occurs also right through Europe, in North Africa, and parts of Asia. The wood known as United States Ash in England is derived from *Fraxinus americana*, and North America yields other kinds such as Red Ash, Blue Ash, Green Ash, Black Ash, Oregon Ash. The English Ash gives the best timber. The white to whitish-brown wood is moderately hard, and very strong, tough and durable. In fact, in strength and durability it comes close to oak amongst British woods. In distinction to many woods, ash is most valuable from quickly grown trees, and the wood of young trees is practically as good as that of old trees.



Photo by N. P. Edwards, Littlehampton

A BIG TREE, CALIFORNIA

Hickory. Under the general name of hickory are included various woods from closely related trees of the genus *Carya*, closely allied to the walnut. This group of trees is entirely confined to North America and some four or six species contribute to the market supply of hickory. The best known characteristic of hickory wood is its toughness, which renders it very useful for many purposes to which ash is adapted.

Boxwood. The Box Tree (*Buxus sempervirens*) is wild in a few places in England, and Box Hill and Boxley owe their names to this plant. It is widely distributed throughout South Europe, North Africa, and Asia, reaching Japan and the Himalayas, and accordingly boxwood has a large number of names indicative of place of origin, *e.g.*, English, Turkish, Corsican, Circassian, Persian boxwood, whilst Papri is one of its Indian names. Two other species of Buxus yield the Cape and Chinese boxwoods respectively. The box is of very slow growth, and never attains a large size. The wood is very hard, dense, and close, with extremely fine grain. In seasoning boxwood splits with a loud report and is very wasteful. In Europe it is chiefly used for turning, wood-engraving, mathematical instruments, and carving and wood-working tools. Owing to the decreasing supply of true boxwood, a very similar wood from the West Indies is largely substituted under the name West Indian Boxwood, also known as Zapatero, White Cedar, Cogwood, and by various other names.

Cedar is a name applied to a large number of timbers which are quite distinct from one another, but agree generally in being light, soft, of fine, even grain and frequently scented



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KAURI TREE FALLING.



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A PHILIPPINE SAW MILL

White cedars and r
cedars are distin
guished according t
the colour of t
timber.

The true cedr
are the Cedar o
Lebanon, the Atl
Cedar, and the Deo
dar, large trees of t
Pine Order.

Another wel
marked group
the Cedrelas, includ
ing West Indi
Indian and Austr
lian Red Cedars
typical cigar-bo
woods. Then w
have the Pencil C
dars, of which Vi
ginian Cedar from
one of the Juniper
the chief. Various
other trees are called
cedars in other
parts of the world
The Cedrelas are
very closely related
to mahogany and
there is much con
fusion between thi
group of cedars and
mahogany.

DEODAR. The beautiful deodar oc
curs in the Himalayas in extensive forests, being most abundant at elevations from 6,000 to 8,000 feet. The deodar is a "cedar," in fact the Cedar of Lebanon and the Atlas Cedar are two varieties of this plant, occurring respectively in the mountains of Asia Minor and Cyprus, and in the Atlas Mountains in Algeria. Botanists classify all three under the name *Cedrus Libani*.

The deodar is the principal timber tree of the Himalayas, and yields the most useful wood of any tree in Northern India. The sapwood is white and the heartwood yellowish-brown, strongly scented, oily, and of moderate hardness. Its chief use is for railway sleepers.

CEDAR OF LEBANON is frequently mentioned in the Bible, and in former times its timber was much used, *e.g.*, in Solomon's Temple at Jerusalem large quantities were employed.

WEST INDIAN CEDAR, MOULMEIN CEDAR, AUSTRALIAN CEDAR. The typical West Indian and South American cedar (*Cedrela odorata*) is a handsome tree yielding the soft, red, fragrant wood of which cigar-boxes are commonly made. Cedar wainscoting is highly esteemed. Owing to the fact that it keeps very free from insects, it is used for the interior work of wardrobes, presses, etc. Havannah, Cuba, Jamaica, or Mexican cedar are other popular names of

thus excellent wood. In the East Indies its place is taken by Toon (*Cedrela Toona*), also known as Indian Mahogany and in England as Moulmein Cedar, from the place in Burma whence it is exported. Its wood is of the same general character and is used in India for furniture, carvings, tea-boxes, cigar-boxes.

A third species, *Cedrela australis*, occurs in Australia, in New South Wales, and Queensland. In the former State it is regarded as the most valuable timber tree, and is extensively used for high-class work such as carriage-panelling, etc., being equal to mahogany.

RED CEDAR or PENCIL CEDAR. Everyone is familiar with this wood, owing to its extensive use in the manufacture of lead pencils. Red Cedar is widely distributed over the North American continent, reaching its greatest development in the southern states. There are two species: the northern Red Cedar (*Juniperus virginiana*) and the Florida Red Cedar (*J. barbadensis*); the latter restricted to the coasts of the southern states and some of the West Indian islands.

The red fragrant wood is light and soft, with very fine, even grain, and these characters render it so suitable for blacklead pencils that it has been calculated that at least 150,000 trees are used annually for this purpose alone. Still larger demands are made on the tree for poles, piles, cross-trees, and other objects in which resistance to weather is important. Other uses include veneering, cigar-boxes, fancy turning, general cabinet work, etc., and it is scarcely surprising that with these many uses the available supply of the tree is rapidly decreasing.

A syndicate has recently obtained rights to work a very similar wood produced by the allied *Juniperus procera*, found in the Mau Mountains in British East Africa.

Another coniferous tree, *Widdringtonia Whytei*, is the principal native timber tree of British Central Africa, and is known as M'lanje Cedar.

CALIFORNIAN REDWOOD (*Sequoia sempervirens*). This red cedar is yielded by a tree which is found nowhere else in the world but in



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A SAW-MILL AND SLIP, MINNEAPOLIS, U.S.



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SAWING KAURI TREE

a strip, from ten to thirty miles broad, along the coast region of California. Redwood is the softest timber of commerce. Although a very large tree, it is entirely overshadowed by its close relation, the "Big Tree" of California (*Sequoia Washingtoniana*), the largest, although not the tallest, tree in the world. Some idea of the great girth of these trees may be gained by noting that the "Mother of the Forest," felled in 1853, was eighty-four feet in circumference and accommodated a dancing party of forty-nine people on the cut stump.

CANADIAN RED CEDAR, GIANT ARBOR VITAE, CANOE CEDAR (U.S.A.), (*Thuya gigantea*). A close relative of the ordinary Arbor Vitae, commonly grown in shrubberies in Great Britain, it attains a height of some 150 feet and a girth of about thirty feet.

Amongst other cedars are the Pencil Cedar of New South Wales and Queensland (*Dysoxylum Frascranum*), New Zealand Cedar (*Libocedrus Bidwilli*), and the allied species *Libocedrus doniana*, of which the native name is Kahata, and Clanwilliam Cedar (*Callitris arborea*).

MAHOGANY was introduced into England about 1724. One account states that some logs were brought as ballast in a ship from British Honduras, and that owing to the hardness of the wood the carpenters refused to use it; but a box made by Wollaston, a cabinet-maker, attracted so much attention that mahogany soon became established in favour. The true mahoganies come from tropical America and the West Indies, but other woods of similar character are conveniently classed as mahogany, and we find African, Australian, East Indian, and other "mahoganies."

The Central American and West Indian varieties are usually stated to be the timber of a large forest tree, *Swietenia Mahagoni* (see p. 297), related to the tree yielding West Indian cedar. Spanish mahogany obtained from Cuba is generally better figured, harder, and of a darker

colour than Honduras mahogany from British Honduras. Cuban Spanish mahogany is hardly ever used now except as a veneer. An inferior variety of Honduras mahogany, softer and of lighter colour, grows on the moist lands around the Bay of Honduras, and is often known as Bay Wood.

All these other mahoganies are of small importance commercially in Great Britain compared with West African mahogany. The mahogany area of West Africa forms an irregular band, parallel to the coast from Gambia to the Cameroons. The timber is of great size, and some of the wood is most beautifully figured and fetches a very high price.

ROSEWOOD. The most important rosewood of commerce is Brazilian, derived from a species of Dalbergia, a leguminous tree. Another name for this variety is Jacaranda wood. The wood has a characteristic fragrant smell, is hard, coarse but even grained, and varies in colour from purplish brown to black. It is highly valued as a furniture wood.

SATINWOOD. There are two satinwoods of commerce, the one from the East and the other from the West Indies. The former is the more important and is usually known as East Indian, Tamil, or Ceylon satinwood. It is obtained from a forest tree (*Chloroxylon Swietenia*) which occurs in Central and Southern India and Ceylon.

West Indian satinwood is very similar in appearance to the preceding, and indeed difficult to distinguish from it, but it usually possesses less "fire," and is almost without figure. It is derived from a species of *Zanthoxylum*, of the Orange family. Its curious greasy smell helps to identify it.

EBONY. The name ebony is commonly applied to any black, hard, and heavy wood, but properly it is limited to the heartwood of species of the genus *Diospyros*.



Photo by N. P. Edwards, Littlehampton

TIMBER LOGS IN THE OTTAWA RIVER

Ceylon ebony is principally obtained from *D. Ebenum*, a large evergreen tree which also occurs in Southern India and the Malay Peninsula. The heartwood only is jet black, the sapwood being almost pure white, so that a section of an entire tree presents a most striking contrast.

ANDAMAN PADAUK or ANDAMAN REDWOOD. This is the principal timber exported from the Andaman Islands, the site of the great Indian convict settlement. The padauk is a very large forest tree, with a very small amount of grey sapwood, whilst the heartwood is bright red with brown and black markings.

TEAK.—The teak tree is one of the most striking of the commercial timber trees of the tropics, its large leaves and huge sprays of light-coloured flowers giving it a very characteristic appearance. It attains a very large size, trees with clean stems of eighty to ninety feet to the first branch, and a girth of twenty to twenty-five feet being recorded.

The area of geographical distribution of the tree includes the greater part of India, Burma, Siam, Cambodia, Cochin China, Java, and other islands of the Dutch Indies. There are plantations in India and Java. The timber is of a uniform brown or yellow-brown colour, greasy to the touch, and of about the hardness of oak. Teak is the principal wood exported from India and Burma, and most of the supplies come to the United Kingdom.

GREENHEART occurs in British Guiana, Brazil, and other parts of South America. It is a very valuable, hard, heavy, tough, and elastic wood of a dark green to brown colour.

LIGNUM VITAE is an extraordinarily hard and heavy wood obtained from *Guiacum officinale*, a South American and West Indian tree. It is dark brown in colour, with black streaks, but the colour is often obscured by a sticky green gum which exudes from the cut surface.

JARRAH is the hard, heavy, dark red wood of *Eucalyptus marginata*, a native of Western Australia. It attains a very large size, and planks of great breadth can be obtained from it. It is exceedingly durable, and is but little attacked by the boring teredo, so that it makes excellent piles. In this country it is most familiar as paving blocks.

KARRI is very closely related to Jarrah, and is the timber of *Eucalyptus versicolor*, locally distributed in Western Australia.

MORA (*Dimorphandra Mora* or *Mora excelsa*) is one of the largest trees of British Guiana, and also occurs elsewhere in South America. Its hard, coarse, dark brown or reddish brown timber has long been known in the United Kingdom, and is rated amongst the first-class timbers at Lloyd's for ship-building. It is said to be more durable than teak.



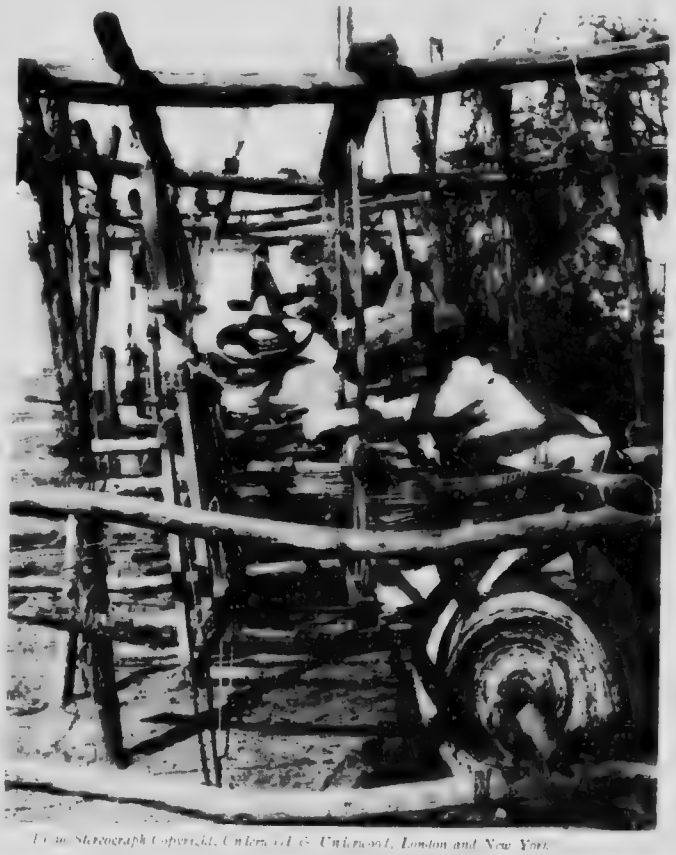
Photo by W. G. Freeman, Esq

THE KAPOK TREE

FIBRES

THE cultivation of fibre-yielding plants and the manufacture of their products into textiles, ropes, cordage, and matting are among the most important industries of the world, and afford employment directly and indirectly to many millions of people. The industries, moreover, are of great antiquity, for we have definite evidence from the Lake Dwellings of Switzerland that flax was cultivated and used as a textile during the Stone Age, and the occurrence of linen cloth in the

tombs of Egypt and constant references to the same material in the earliest books of the Bible are well known to everyone. How and when mankind first became aware of the possibilities of vegetable fibres as materials for clothing it is not easy to say, but it is not improbable that he first employed the fibres to supply his need for string and cordage, especially in his hunting expeditions, and that gradually the idea of weaving the strings to form a fabric occurred to him. The apparatus employed must have been of extreme simplicity and the finished product crude according to modern ideas; but that thousands of years ago textiles of superlative quality, rivalling anything that can be produced to-day, were manufactured by Eastern races is a matter of history and observation.



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NATIVES MAKING MATTING, MONTENEY, MEXICO

The fibres employed at the present day by both civilised and uncivilised peoples are as numerous as the uses to which they are put, and in classifying them for purposes of description, there is choice of several alternatives. To the practical man, however, classifications, although of considerable interest, are of little value. He is inclined to look upon all fibres as suitable for textiles, sacking, ropes, cordage, matting, packing, and numerous other purposes. In this article it is proposed to deal with the fibres from this point of view. It should be realised, however, that an absolute economic classification of uses with relation to species is impossible, since the same fibre may be used in several ways. Manila hemp, for instance, is chiefly used for rope-making, but old manila is made into paper: cotton is used for textiles, but also for cordage, upholstery, and paper. In the space at our disposal it is quite impossible to describe all the fibres met with in commerce, but the most important have been dealt with. Cotton is of such great importance as to demand treatment in a separate article (*q.v.*).

FABRIC FIBRES

Flax

Flax was one of the earliest plants cultivated for fibre, and from the times of the first authentic record until the advent of cheaper cotton during the last century it was more extensively used than any other. The flax-plant, *Linum usitatissimum*, probably originated in Western Asia, but at the present day it is extensively cultivated in northern and



Photo by Charles Abraham

CARRYING HEMP

central Russia, Belgium, Holland, France, Italy, Ireland, United States, and Canada, and, next to cotton, flax is, commercially speaking, the most important fibre plant of the world. In some countries, such as India, Central Russia, Argentina, and the United States, large areas are also under flax, but the plant is here almost exclusively cultivated as the source of linseed oil.

Probably the best flax on the market is that grown in Belgium, and great care is taken in the cultivation of the crop. The principal flax-growing district is around Courtrai, where conditions are exceptionally favourable for the plant and for the preparation of the fibre. As in Ireland, flax is grown in rotation with other crops, few farmers caring to sow flax at more frequent intervals than once in every eight years, and the greatest success is obtained when the intervals are even longer. In Ireland the plant is "pulled" or gathered when the lower leaves are beginning to fall, but in Belgium it is allowed to attain greater maturity. The greatest care is exercised in pulling the plant, the process being carried out by hand; the stems are arranged so that the roots are all at the same level, and then the handfuls of the "straw," as it is called, are piled in stooks to cure or dry. After this it is placed in ricks of bundles which are so packed together as to allow of perfect ventilation, and finally, after the seed has been removed by threshing, the straw is stacked previous to the retting process which allows of the easy separation of the bast fibre from the remaining vegetable tissue.

Preparation. The retting or steeping, which depends ultimately upon the action of bacteria, is carried out in three different ways in various parts of the world. The simplest method, known as dew-retting, is that adopted in North America and Russia, where the bundles are simply spread evenly over the surface of a damp meadow, and the natural moisture of the soil, dew, and rain allowed to separate the bast from the woody tissue. In Ireland the flax is retted in pools of soft water, the pools being either natural or artificial. The sheaves are packed loosely under water so that, if possible, they do not come in contact with the bottom of the pond, and after

about ten days the fibre sinks to the bottom of the pond, and the process of decomposition is regarded as complete. The turbidity of the water during the whole period indicates the activity of the fermentative organisms.

In Belgium the straw is retted in the river Leys, the water of which is said to be unrivalled for the purpose. The bundles are closely packed in crates, the tops of which are covered with straw to keep out any foreign matter, and the whole is then placed in the water for from four to fifteen days. The straw is again dried in little stooks in the fields and then subjected to a second, and sometimes a third, immersion, when the steeping process is complete. When the flax is considered to be sufficiently retted it is finally dried in the fields, and then subjected to a "breaking" process which fits it for the final scutching. The breaking is effected by machinery, and consists essentially in breaking up the stems of the plants between rollers in order to separate the woody tissue from the fibre or flax. The more thoroughly the breaking is performed the less will be the amount of scutching required, and consequently the quantity of waste material will be reduced. During the scutching process the fibre is freed from the woody particles and rendered fit for the market. Hand-scutching still survives in some countries, but scutching machines are extensively employed in all the great flax-growing districts. During the process the broken stems are subjected to the action of revolving blades which beat out all the woody fragments, and, when quite clean, the finished fibre is removed to the store, and there finally baled for the market.

Flax fibre is from twelve to thirteen inches in length, and varies in colour from silvery grey to yellowish white, according to the method of retting employed. It is the strongest of the commercial plant fibres, but, nevertheless, is soft and flexible, and is extensively used for making table linen, handkerchiefs, collars, sewing thread, and bookbinders' twine.



Photo by Charles Abéniacar

THE CULTIVATION OF HEMP: RESTING

Hemp

Many fibres are known commercially as "hemps," *e.g.*, Sisal Hemp, Manila Hemp, and Bowstring Hemp, but the true hemp is the bast fibre of *Cannabis sativa*, a plant native to western Asia, and belonging to the stinging-nettle family (*Urticaceae*). Like flax it was cultivated for centuries before the Christian Era, and next to flax was the most important vegetable textile material before the introduction of the cheaper cotton and jute. The principal hemp-growing countries are Russia, Austria, Italy, Turkey, China, Japan, and the United States. Throughout the East the plant is cultivated chiefly as a source of the intoxicating drug known as "bhang."

The plant reaches a height of from four to ten feet, and under especially favourable circumstances a height of twenty feet is not uncommon. Some of the finest grades of hemp come from Italy, where the plant is largely cultivated, and an account of the Italian methods of cultivation and preparation will be of interest. Great care is taken in preparing the fields for the seed, and manuring is very thoroughly carried out. The crop is considered ready for harvesting when the tops of the plants begin to turn yellow, and the male plants, which yield the best fibre, are always cut before the female. The stems are then gathered in bundles and placed on trestles to dry, when they are ready for the next process, viz., that of retting in water. After the retting is complete the stems are carefully dried, either in the open air, a method which results in a fibre of superior colour, or else by artificial heat in ordinary bread ovens. Drying in the open air takes from three to six days, and a great point in favour of the employment of artificial heat is the rapidity with which the drying can be effected. The next process is the removal of the external bark from the stem, and this decortication, as it is called, is carried out in various ways, either by hand-beating or by the employment of very simple and primitive contrivances.



Photo by W. G. Freeman, Esq.

BORASSUS PALM

The best varieties of hemp are creamy-white in colour, lustrous, soft, and pliable. The fibre furnishes a satisfactory substitute for flax, and, except for the finer linens, is employed for medium grades of nearly all goods commonly made from flax. It is also very largely used for cordage, ropes, and fishing-lines, and is extensively employed in the carpet and rug trades.

Jute

Jute is said to be yielded by several species of Corchorus, but only two species, *C. capsularis* and *C. olitorius*, are cultivated for their fibre. The plants are regarded as natives of India, where they are extensively grown, especially in the province of Bengal, and they are also cultivated to a limited extent in China, Malaya, and Formosa.

Corchorus is a genus of the *Tiliaceae* (Lime tree family), and the two fibre-yielding species are annual plants growing to a height of from five to ten feet with a round stem about three-quarters of an inch in diameter. *C. capsularis* and *C. olitorius* are very similar in habit of



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MAKING ROPE IN MANILA

growth, but are readily distinguished by the seed-pods, which in the case of the former plant are almost globular and in the latter cylindrical, and about two inches long. There are numerous varieties of the two species, but the fibre yielded is fairly constant in character, and for the purposes of this article the varieties will be treated of collectively.

Jute grows best in a hot, damp atmosphere, and flourishes especially in a highland district. The seed is sown in the spring either broadcast or in nurseries, whence the seedlings are afterwards transplanted. Harvesting takes place about three months later, when the plants



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NATIVES MAKING ROPE, MONTENEY, MEXICO

are in flower, and the method employed is either cutting with a sickle or pulling up the whole plant by hand. The stalks are gathered into bundles and placed in stagnant water to undergo a retting process, which is effected in varying periods of from two or three days to a month. While the bundles are under water they are examined from time to time, and, when the fibres separate readily, the bundles are taken from the water in preparation for the final separation of the fibre from the stem. Various methods are adopted, a common one being for the operator to beat or shake the stems in water until all the resinous matter of the bark is washed away. The man stands in the water, takes as many stems as he can conveniently hold, and strips off the bark in long strands. This completed, he dashes the remaining fibre upon the surface of the water until it is freed from vegetable débris, and after a further washing the jute is wrung out, dried upon lines, and finally made up into hanks for the market.

The uses of jute have been recognised in India from the most remote times, but the employment of the fibre as a textile by Western peoples dates back only to the last century, the first recorded export of jute from India being in 1828. Jute is most largely used for the manufacture of "gunny" bags and cotton baling, but is also a most important cordage and twine material; the waste material resulting from these manufactures is used in paper manufacture. Dundee is the centre of the jute industry in Great Britain.

Ramie, Rhea, China Grass

Ramie, Rhea, or China Grass, is an example of a product which, were it not for the difficulty and expense of its production, would probably occupy a most prominent place on the market. The fibre is without doubt one of the strongest and finest known; it is brilliantly lustrous and silky, very durable, and is said to be less affected by moisture than any other fibre. Moreover, it is of exceptional length, and can be dyed readily.

No small amount of confusion has hitherto existed with regard to the fibres variously known to commerce as China grass, ramie, and rhea, and even at the present time there is constant evidence that the confusion still exists. Briefly put, the facts are that the fibres

of two distinct but closely related plants are described under the three trade names given above. "China grass" is obtained from the stems of *Bochmeria nivea*, and "rhea," or "ramie," from the stems of a variety of this plant, *B. nivea*, var. *tenacissima*. Both plants, which belong to the stinging-nettle family, *Urticaceae*, have somewhat the habit of a gigantic nettle, but *B. nivea* flourishes in temperate countries, and is characterised by the white under-surface of its leaves, while, on the other hand, *B. nivea*, var. *tenacissima*, requires a more or less tropical climate for its best development, and has under-surface of its leaves green. The term "ramie," however, is applied in commerce to the product of both plants.

The true China grass is prepared in China entirely by hand. The first process is the stripping off from the stem of the outer skin containing the bast. The long strips are known technically as "ribbons," which are then deprived of the external epidermis by scraping and washing, and in the resulting product the fibres are embedded in a more or less gummy substance which it is by no means easy to remove satisfactorily. The scraped ribbons are then subjected to the "de-gumming" process, but if the fibre is intended for export this process is not carried out in China, since the merchants of Europe and America prefer to de-gum the fibre in their own mills. The hand-preparation of the fibre, however, is slow and expensive, and consequently numerous attempts have been made to invent suitable machinery to do the work. Large rewards have been offered from time to time, notably by the Indian Government and the Commissioners of the Paris Exhibition of 1889 for suitable mechanical processes, and at the present day the difficulty of decorticating ramie stems by machinery may be regarded as solved. There are two kinds of ramie machines, namely, those which merely strip the bark in ribbons from the stems, and those which not only decorticate the stems, but also remove more or less completely the epidermis from the ribbons, and afford a material resembling hand-cleaned China grass.

The next stage is the de-gumming process, but although many methods have been devised to this end, they are all more or less jealously guarded as trade secrets, and it is difficult to state the actual details of the process. Essentially, however, the various methods consist in boiling the ribbons in dilute soda, and then exposing them to the action of bleaching powder and subsequently to that of a dilute solution of acid, until the whole of the gum has been removed.

The result of this treatment is the production of



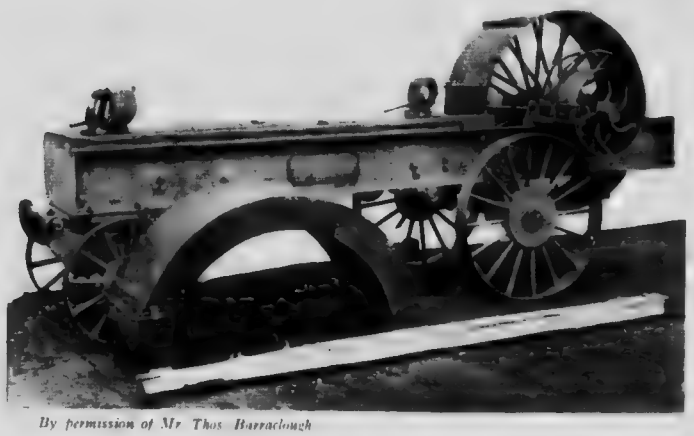
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A LOAD OF MANILA HEMP AT CUBA

a fine, white, lustrous fibre known as "filasse." The fineness and strength of ramie suggests its use for the manufacture of many materials for which cotton, wool, and flax are now employed. It is woven into goods of various descriptions such as lace curtains, handkerchiefs, damasks, tablecloths, etc., affording a material of exquisite texture, and it has also been used for plush and carpets

Pine-Apple Fibre

Although the pineapple plant (*Ananas sativa*, Natural Order *Bromeliaceae*) is usually grown for its fruit, in some parts of the East, notably in the Philippines and the Malay Peninsula, the fibre yielded by the leaves is the object of the cultivation of the plant. The plant is low-growing, and the leaves are about three feet long and one to two inches wide. To obtain the fibre, the leaves are scraped with a bamboo instrument resembling a plane, or in the Philippines merely with the sharp edge of a piece of pottery. Modern machinery, however, is also nowadays employed. The fibre obtained is washed in water and then dried in the sun. It is white, soft, flexible, and very durable, even when exposed to the action of damp. The celebrated Piña Cloth of the Philippines is prepared from this fibre, and the Chinese employ it in the manufacture of a coarse, strong fabric. The inhabitants of Formosa also use it in making some of their clothing.



By permission of Mr Thos. Barraclough

PORTABLE SCUTCHING MACHINE

ROPE, CORDAGE, AND MATTING FIBRES

Manila Hemp, often known as Manila fibre or abaca, is obtained from the leaf-sheaths of a non-edible banana, *Musa textilis*, found in the Philippines. Until quite recently it was supposed that this valuable fibre was yielded by one species, but the researches of the United States Department of Agriculture have lately shown that there are probably several distinct but closely related species, all of which yield the commercial fibre.

The plant is cultivated in a comparatively small portion of the Philippines, the chief districts being Luzon, Mindanao, Negros, Mindoro, Cebu, and Samar, where the humidity of the atmosphere is relatively high. The best localities are the sides of hills of volcanic origin, where good natural drainage exists, for it has been found impossible to cultivate the plant in swampy water-logged soil, or, on the other hand, in soil which rapidly becomes dry.

The plant is propagated chiefly by the suckers or plantlets which spring from the roots of the mature plants. About three years are required for the suckers to reach maturity, but seedlings take a considerably longer period, generally about five years. The plants attain a height of from eight to twenty feet, the "stem" being composed of overlapping leaf-sheaths.

When the flower-bud appears the whole plant is cut down close to the ground; the leaf-sheaths are stripped off, sliced horizontally into layers about $\frac{1}{4}$ of an inch thick, and these in turn split into strips about two inches wide. While still fresh the strips are drawn under the edge of a blunt knife-like instrument held against the surface of a board, the process freeing the fibre from the pulp of the leaf-tissue, and leaving it clean and white.



The finest grades of Manila hemp are of a light buff colour, [illegible] very strong, the [illegible] fibres occurring in strands about six to twelve feet in length. Inferior qualities are coarser and duller in colour, and are lacking in strength. The fibre is regarded in the trade as unrivalled for rope-making, especially for cables, hawsers, and other marine cordage.

Sisal Hemp

There are two varieties of Sisal hemp met with in commerce, viz., the sisal of Yucatan (*Agave rigida*, var. *elongata*) and the sisal of the Bahamas and Florida (*A. rigida*, var. *sisalana*). The latter, which is known as "henequen," is by far the most important, and is the subject of valuable industries in the Bahamas, Mexico, Turk's Island, Cuba, and Hawaii. Of late years the cultivation of the plant has been experimented with in India, especially in the Bombay and Madras Presidencies, and quite recently the trial plantations in German East Africa and British East Africa have produced sisal of the finest quality.

The plant requires for its most satisfactory development a soil composed chiefly of lime-stone, but it does well on most stony, dry soils. The plantations are laid out from suckers as in the case of Manila hemp, or from the bulbils which appear on the flower-stalks in the positions of the withered flowers, much in the same way as "sets" occur on onion plants. The plants are set in holes during the rainy season, and practically the only attention given to the fields is the clearing away of weeds about once or twice a year. In this case it is the long sword-shaped leaves of the plant, armed with prickles along the margins, which yield the fibre, and the first crop of the outer leaves is cut at the end of the third or fourth year, according to whether the plants were grown from suckers or are "mast plants" from the bulbils occurring on the flowering "mast" or "pole." In Yucatan an average of about fifteen leaves is obtained annually for a period of about twenty-five years, and in the Bahamas the same number is obtained for from six to twelve years. At the end of these periods the plants send up the flowering stem, and when once the flowering is over the plants die.



Photo, W. H. de Lissa, Esq.

COCO-NUT VEGETATION

The machines used to separate the fibre from the leaves are generally known by their Mexican name of "Raspador," which sufficiently indicates their essential action. The leaves are fed into the machine which effectively scrapes out the pulp and at the same time washes the fibre in water which is kept running in a steady stream to remove all *débris*. The fibre is then hung in the sun to dry and bleach, a process which occupies about two or three days.

Sisal is a straight, smooth, and clean fibre of a yellowish-white colour, measuring from two-and-a-half to four feet in length. Next to Manila hemp it is the most valuable of the hard cordage fibres.

The genus Agave possesses several species yielding valuable fibres, and next in importance to the sisal plant is the American Aloe or Century Plant, *Agave americana*. This species, which receives its name of Century Plant from the fact that it flowers only at long intervals and



Photo by Chas. Aleinitzer

GATHERING HEMP

then dies, is cultivated in Mexico, where it is known as "Maguey," while the fibre yielded by it is described under the native name of "pita."

Istle, or Mexican Fibre, is yielded by five or six species of plants growing on the arid tablelands of northern Mexico, but the greater part of the fibre is obtained from the leaves of *Agave heteracantha*. Istle is employed in the manufacture of the cheaper grades of cordage.

Phormium Fibre

Phormium fibre, often incorrectly known as New Zealand Flax or Hemp, is obtained from the leaves of *Phormium tenax*, a plant belonging to the Lily family (*Liliaceae*), and found wild in New Zealand, Norfolk Island, and the Chatham Islands. The plant is said to be unrivalled for its yield of fibre, the sword-shaped leaves, which measure from five to ten feet in length, giving upwards of fifteen per cent. of their green weight as cleaned fibre.

The Maoris have long been known to prepare a most excellent fibre from Phormium by hand, and even at the present day the machine-prepared product cannot approach the native article in quality. The hand-made fibre, however, is much too expensive to be able to compete successfully with other commercial fibres, and in all the mills controlled by Europeans machinery is employed. The leaves are first crushed between heavy rollers, and the soft tissues stripped off by beaters attached to a revolving drum. The fibre is then very thoroughly washed in running water, and afterwards exposed to the drying and bleaching action of the sun. After being further cleaned and straightened it is made up into hanks and baled. Within recent years the New Zealand Government has required that all Phormium fibre exported shall be graded into definite qualities recognised by their officials, an action designed to maintain the reputation of the fibre upon the world's markets by guaranteeing to merchants an unvarying quality of the product. Phormium fibre is soft, nearly white in colour, with a silky lustre, and its breaking strain is stated to be higher than that of either hemp or flax.

Bowstring Hemps

These fibres, which receive their names from the fact that the natives in various parts of the world are said to prepare their bowstrings from them, are derived from the leaves of several species of Sansevieria, an important genus of *Liliaceae*, with representatives in the tropical regions of both the Old and New Worlds. They occur in Ceylon, on the West Coast of Africa, and in the East Indies extending from Bengal to Java and China. The most important species are *S. guineensis*, a native of Guinea, and found in the West Indies, Central America, Abyssinia, and Mauritius; *S. Roxburghiana*, a well-known plant of India; *S. cylindrica*, occurring in South Africa; *S. longiflora*, a native of equatorical Africa, but now

distributed to tropical America, occurring abundantly in Florida: *S. chrenbergii*, found in East Africa; and *S. Zeylanica*, cultivated in Ceylon. All the species are perennial, stemless plants with thick, fleshy, usually sword or lance-shaped root leaves, which yield the fibre.

S. guincensis is the best-known species producing bowstring hemp, and, as stated above, is found on the West Coast of Afr a, in Central America, and in the West Indies, the principal locality being Jamaica.

Mauritius Hemp

Mauritius hemp is yielded by the leaves of *Furcraea gigantea*, a plant belonging to the *Amaryllidaceae*, the natural order containing such familiar plants as the Snowdrop and Daffodil. Furcraea is closely allied to the Agaves, and like them possesses a massive long-lived stem with immense fleshy leaves; the flowers are produced, after a long period, upon tall central stems.

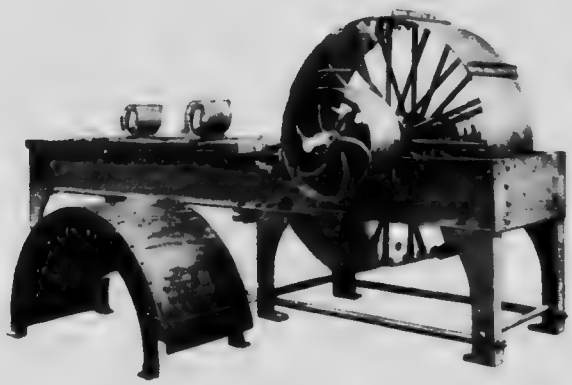
The plant is found throughout tropical America, but the fibre is produced commercially only in Mauritius, where the industry is most important. The preparation of the fibre involves processes essentially the same as those employed for sisal, viz., scraping, washing, and drying. The fibre is softer and whiter than other hard fibres, and is weaker than sisal.

Sunn Hemp

The plant producing this fibre is *Crotalaria juncea*, a member of the Pea family, *Leguminosae*. It is a tall shrub growing from eight to twelve feet high, with a branching furrowed stem, and is extensively cultivated in India, more especially in the North-West Provinces. The seed is generally sown with the advent of the rains, and it is important to sow the seed thickly in order to avoid the bushy branching habit of the plant, which would result if abundance of room were allowed for development. The fibre is obtained from the stems which



NEW ZEALAND FLAX



By permission of Mr. Thomas Barraclough

SCUTCHING MACHINE

are either cut with a sickle or pulled up by hand. Bundles of the stems cleared of the leaves are placed in water for the retting process which is complete in a few days. The operator then separates the bark and wood from the fibre in a way very similar to that employed for jute, viz., by dashing the retted stems upon the surface of the water until the cleaned fibre becomes separated. The drying is effected by hanging the fibre upon bamboo supports exposed to the sun, a process which also bleaches the fibre.

Coir

Coir, or coco-nut fibre, is obtained from the outer husk of the coco-nut, the fruit of the coco-nut palm, a tall graceful tree from sixty to a hundred feet high, bearing a crown of large feathery leaves and spikes of small flowers. In commerce, the chief coco-nut products are oil and fibre, the latter being known to the trade as "coir." The ripe coco-nut as it occurs on the tree is a large, oval body, angular in section, and with one end somewhat pointed; the thick outer husk is composed of fibres densely packed together, and surrounds the "nut" so familiar in this country. In preparing coir for the market, the object is to separate the outer husk from the inner nut and to obtain the cleaned fibre. In Ceylon the husks are split open by forcing them against a pointed stick fixed in the ground. The next process is to soak the husks in water, the soaking being carried out either in pits or in brick, iron, or wooden tanks into which steam can be admitted to warm the water. Great care is taken to avoid over-soaking, but when the husks are sufficiently softened they are beaten with wooden mallets and then rubbed between the hands until all the interstitial tissue has been removed from the fibre, which is then ready for drying. In the European factories, however, machinery has been substituted for hand labour.

Coir fibre is coarse, clean, stiff, and very elastic, and although not of great strength is largely used in the East as a rope and cordage material on account of its power of withstanding the action of sea-water.

The screw pines also afford a useful matting material. Their leaves are cut into strips, and used for making bags, mats, wrappers, etc.

"Russia mats" are made from strips of the inner bast of the Lime tree.

BRUSH FIBRES

An important application of vegetable fibres in the arts is for the manufacture of brushes and brooms. In a few cases the stems of the plant are sufficiently fine and elastic to be used directly for the purpose, as in the case of the Broom Millet, where the fruiting stalks are cleaned of the seed and used for the well-known "Venetian whisks" of Italy, and for other kinds of brushes. The roots of the Mexican grass, known to the trade as "Broom root," are also imported into Germany and France, where they are manufactured into cheap brushes and shipped to the United States. Again, the roots of Khus Khus grass, a native of India, are said to be used by the weavers of that country in arranging the threads on the loom, although the fibre is best known as the material from which the fragrant screens, or "tatties," are made.

Among the most important of the tree fibres used for brush-making, however, are the various "basses" or piassabas (piassavas), from which bass brooms are made. These coarse dark-brown or black fibres are obtained from the leaf-stalks or leaf-sheaths of various species of palms growing in tropical America and Africa.

Bahia piassaba is derived from the leaf-stalks of a large handsome palm with pinnate leaves, abundant in swamps and on river banks in the province of Bahia, Brazil. Very little preparation of the fibre is required, for it naturally separates from the leaf-stalks in a fringe of coarse, flexible, somewhat flat strands. The mass of fibres is removed by the natives with a small axe, and, after a simple cleaning and straightening process, the piassaba is baled for the market. It is largely employed for the brooms used by street scavengers.

Leopoldinia piassaba, a palm also found abundantly in Brazil, yields Monkey Bass or Para piassaba. The fibre, which resembles the former variety in essential qualities, is also obtained from the leaf-stalks, which, where they clasp the stem, become expanded and produced into ribbon-like strips and separate into fine, almost round fibres about five feet long.

A fibre which is finer and more flexible than Para piassaba is that known as Madagascar piassaba, obtained from the leaf-stalks of *Dictyosperma fibrosum*, a palm occurring in the island.

Fibres similar to those described above are afforded by other species of palms, the most interesting being the stiff, wiry, Palmyra fibre obtained from the sheathing leaf-stalks of *Borassus flabellifer*, a tree found truly wild in tropical Africa, and extensively planted in the East Indies, and Kitul fibre prepared from the corresponding parts of the Kitul palm, a characteristic plant of India and Ceylon. Kitul fibre is dusky brown in colour, and, after being straightened and rendered more pliable by soaking in linseed oil, is largely used for making soft long-handled brooms. The sago palm of Malacca also yields a rich black fibre remarkable for its durability and known in the East as Gomutu or Ejoo fibre. It is extensively used by the natives for ropes, caulking ships, stuffing cushions, etc., but only the coarsest qualities are suitable for brush-making.

PAPER-MAKING FIBRES

The essential constituent of paper is cellulose, and paper-makers depend entirely upon vegetable fibres for their supply of this material. There are really very few fibres which cannot be made into paper of varying qualities, the amount of cellulose they contain and the cost of manufacture being the main considerations. A large quantity of paper-making material is obtained from the waste of jute and rope-making mills, but at the present day probably the most important source of material is found in wood pulp, which is merely timber, preferably coniferous, reduced to a soft pulp by mechanical and chemical means.

Esparto grass affords another valuable paper-making material. It grows in North Africa and Southern Spain, occurring in dense tufts on rocky and sandy soils, and reaches great luxuriance near



BORASSUS PALMS



GIANT ALOE, BARBADOES

the sea-coast. There are four chief varieties, viz., Spanish, usually regarded as the best, Algerian, Tunisian, and Tripoli, the last three being in order of excellence. The paper manufactured from this grass is pliant, strong, transparent, and of great purity, but cannot compete in price with the cheap qualities made from wood pulp. A grass very similar to esparto in its paper-making qualities is the Bhabur grass of India. The straw of numerous cereal grasses is also used where obtainable, wheat, oats, and barley being employed in Europe, and rice in Asia, but the papers are of a low grade, and much inferior to esparto paper.

The fibrous inner bark of the Baobab tree (*Adansonia digitata*) was also at one time used to a fair extent for paper, but its use has now declined.

The paper used so largely by the Japanese for lanterns, umbrellas, and books of all kinds, is made from the young shoots of *Broussonetia papyrifera*, the paper mulberry, which is widely distributed throughout Eastern Asia and Polynesia. The plant is also interesting as the source of the famous Tapa cloth of the South Sea Islanders.

Chinese rice paper is prepared from the pith of *Fatsia papyrifera*, a plant common in Formosa.

A paper, common in India, and known as "Nepal" and "Daphne" paper, is made by the hill tribes of Nepal from the bast fibres of *Daphne cannabina* (*D. papyrifera*), and one or two other closely allied plants. The paper is remarkably tough and smooth and has received high commendation from English experts.

The "Papyrus" of the ancient Egyptians was obtained from the pith of *Cyperus Papyrus*, a sedge formerly largely cultivated on the banks of the Nile in Lower Egypt. The plant is now found on the river banks of Abyssinia, Sicily, and Palestine, and is one of the principal constituents of the "sudd" or masses of floating vegetation found in the Upper Nile. The papyrus was prepared by pressing together strips of the pith previously soaked in water.

The "Ola leaves" largely used as a writing material by the natives of Ceylon in former times, was prepared from strips of the young leaves of the beautiful Taliput Palm.

SILKS AND FLOSSES

These fibres are found attached to the seeds or the walls of the seed pods of various plants, and, biologically speaking, are intended to aid in the dispersal of the seeds by the wind. They are, therefore, very similar to cotton from a botanical point of view, but, unlike

this fibre, they are practically useless for textile purposes since the ultimate fibres are circular in section and lack the characteristic "twist" of the cotton fibres.

The most important of the silk cottons is "Kapok," the seed hairs of *Eriodendron anfractuosum*, the white silk-cotton tree of the East Indies. Various unsuccessful attempts have been made to employ it as a textile, and it is chiefly used for stuffing upholstery. It has also been employed as a buoyant material for packing life-belts. The best qualities of kapok are obtained from Java. The red silk-cotton tree, *Bombax malabaricum*, is a native of India, but the floss, although of good quality, is considered to be inferior to kapok.

The Down tree of tropical America and Jamaica, known botanically as *Ochroma lagopus*, affords a beautifully soft fawn-coloured floss, which is densely packed in the long angular pods.

Cochlospermum Gossypium, an East Indian plant, also yields a good silk cotton, but it has no recognised position on the market. There are many other vegetable flosses or "silks," as they are sometimes called, and space permits the mention of but a few. The well-known "mudar" floss (*Calotropis gigantea*) is beautifully silky, and the natives of India affirm that it has a soothing effect when used in pillows. "Yachan" floss is obtained from *Chorisia insignis* in Argentina, and other flosses are yielded by species of Asclepias and Beaumontia, that of *B. grandiflora*, a plant growing in Bengal, being especially fine.

MISCELLANEOUS FIBRES

The Tapa cloth of the Pacific Islanders has been referred to under "Paper-making Fibres." The famous Uganda Bark Cloth is prepared by beating the bark of a species of *Ficus* with curious grooved mallets of hard wood until the *débris* has been got rid of and the material rendered supple. The Lace Bark of Jamaica is the bast of *Lagetta lintearia*, and is well known as a fancy material for cravats, frills, fans, and wall ornaments. The popular Panama hat is plaited from strips of the young leaves of *Carludovica palmata*, a palm-like plant growing in Central and South America. The less well-known Ippi-Appa hat of Jamaica is made in a similar way from the leaves of *C. jamaicensis*. The Mallow family (*Malvaceae*), to which the cotton plant belongs, is particularly rich in fibre-yielding plants, and some of the most interesting occur on the genus Hibiscus, a group of plants distinguished by their large showy flowers. "Deccan" or "Ambari" Hemp is obtained from the stems of *H. cannabinus*, cultivated for its fibre in most parts of India.

The inner bark of *H. elatus*, a tree occurring in the West Indies, affords the Mountain Mahoe, sometimes known as "Cuba Bast," used for hats and for other millinery purposes.



LABOLABO COTTON FARM, GOLD COAST

COTTON

COTTON is the most important material used for man's clothing, having during comparatively recent

years almost entirely supplanted linen. Cotton, too, has successfully competed with wool, and such materials as flannelette are entirely made of cotton, whilst fabrics of mixed cotton and wool are much more common nowadays than in former times. Scientific discoveries have enabled cotton to be so treated that it appears almost exactly like silk, with the result that cotton velveteen and sateen are made on a large scale and form cheap substitutes for velvet and satin, which are made of silk. Mercerised cotton can be made to resemble silk so closely that many "silks" are so only in name. Cotton is so useful to civilised man that this one plant can supply him not only with cotton clothing, but also to a certain extent with substitutes for wool and silk. To the uncivilised races of the world, whose needs are simpler, cotton is again most important, and all kinds of native garments, ranging from the simple loin cloth of primitive people to the elaborately decorated robes of other races, are made entirely of cotton.



Photo by E. Minoprio, Esq

A SOUTHERN COTTON PLANTATION, U.S.A.

Cotton was well known and in common use in India long before the Christian era, for in an old book written about 800 B.C. the plant is referred to frequently, and in such a way as to show that it was quite familiar. Nearchus, the admiral of Alexander the Great, who took part of his army along the shores of the Arabian and Persian Gulf about 327 B.C., says: "There are in India trees bearing as it were bunches of wool. The natives made linen garments of it, wearing a shirt which reached to the middle of the leg, a sheet folded about the shoulders, and a turban rolled round the head, and the linen made by them from this substance was fine and whiter than any other." India was the centre of cotton cultivation and manufacture in the early days and for long afterwards. Indian cotton goods were sent to many parts of the world, and our word "calico" was originally given to this familiar material because it came from the Indian port of Calicut. From India cotton plants were probably sent to China and other neighbouring countries.

Later explorers found cotton in other regions. For example, in 1492, Columbus noted that it grew abundantly in the West Indies and on the neighbouring coasts of America, and that the natives had considerable skill in making it up into cloth. In Mexico, Peru, and Brazil, cotton was well known and in Mexico was the chief article of clothing. In parts of tropical

MAP OF
THE WORLD
SHOWING
The Cotton Producing
Countries
Steamer Routes
NORTH AMERICA
SOUTH AMERICA
AFRICA
AUSTRALIA
ASIA
EUROPE
GREENLAND
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
CHINESE EMPIRE
JAPAN
PERSIA
SUDAN
TIBET
Meridian 0 of Greek



Photo by Putnam and Valentine

SHIPPING COTTON AT NEW ORLEANS

Africa cotton grows wild, and is used by the natives to make cloths.

The cotton plant belongs botanically to the Mallow Order or *Malvaceae*, and is closely related to the ordinary wild mallows and to the hollyhocks of our gardens. Most of the species are shrubs or small trees, and in warm countries are perennial. A winter, however, kills the plants, and in the United States new plants have to be raised from seed every year. This practice is also carried out when cotton is cultivated in countries which have no winter, as it frequently gives better results than when the plants are allowed to grow for several years.

Cotton plants have large yellow, white, or red flowers, not unlike rather small hollyhock flowers, and each flower forms a capsule or "boll." When fully ripe the boll splits into three pieces, and displays the white cottony mass, consisting of a number of seeds, each having firmly attached to it a dense covering of fine hairs, which are the raw cotton of commerce.

COTTON-PRODUCING COUNTRIES

Cotton is distinctly a warm-climate crop, and a glance at the map of the cotton-growing regions of the world shows us that it is grown in almost every part of the earth between about 40° N. and 30° S. of the Equator. In America the principal regions are the south-eastern part of the United States, Central America, the West Indies, Brazil, Mexico, and Peru. In Europe small cotton areas are found scattered around the Mediterranean, in Spain, Italy, Turkey, and Greece. India, China, Japan, Persia, and Asia Minor are in their order the chief cotton-producing countries of Asia. In Australia cotton is only grown to a very small extent, chiefly in Queensland, South Australia, and New South Wales. Africa is an important contributor to the world's cotton supply owing to the great amount grown in Egypt; on the west coast Lagos has a considerable export, and efforts are being made to extend cotton cultivation in Nigeria and elsewhere. Rhodesia, East Africa, and Madagascar also either produce cotton or are likely to do so in the near future.

Although cotton is grown in so many places, most of the world's commercial supply is obtained from three countries—the United States, India, and Egypt. The United States produce about six-tenths of the world's supply, India about two-tenths, Egypt one-tenth, and all the rest of the world together only the remaining tenth. The United States control the cotton market, and any diminution in the supply from this source, due to a short crop or to artificial manipulation by speculators, entails grave consequences to the vast cotton industry in Lancashire. Such a shortage was brought about by the American Civil War in 1864, when the price of cotton reached a very high figure, and much distress was caused in England. Again,

in 1902, there was another natural shortage in the supply from America, which was made worse by the action of speculators endeavouring to form a "corner" in cotton, and mills in Lancashire had to close, or work only for part time, causing much hardship to the operatives. To endeavour to guard against the repetition of such occurrences, the British Cotton Growing Association has been formed to promote, with the co-operation of the Government, the cultivation of cotton in the British Empire, and to make England to some degree independent of the American supply. More recently British cotton spinners have taken action with a view to themselves becoming cotton producers in the United States. Much experimental work has been carried out with the aid of the British Cotton Growing Association in various colonies. The old cotton industry in the West Indies has been revived, due in great measure to the activity of the Imperial Department of Agriculture for the West Indies. The dormant cotton industry of Lagos has taken new life and increased enormously. Northern Nigeria offers immense fields if proper transport can be provided. In East Africa and various other parts of the world it has been proved that good cotton can be grown. Steps are being taken to improve the grade of cotton produced in India, which, although it now yields large crops, does not supply cotton of sufficiently good quality for the English market.

The French, German, Portuguese, Italian, and Dutch Governments are also making efforts to extend cotton cultivation in their colonies, and in a few years' time it will be demonstrated which countries are able to produce cotton of good enough quality and at sufficiently low cost to compete in the world's markets with that from the present established sources of supply.

Varieties

There are numerous varieties of cotton, but for commercial purposes we can confine our attention to the most important.

Upland or American Cotton. This is the kind in the greatest demand. It is obtained from a plant known as *Gossypium hirsutum*, originally perhaps a native of Mexico, but now cultivated in the United States and in other parts of the world. Each seed bears both long and short hairs, the latter remaining attached to the seed after the long ones are removed, so that the seeds present a "fuzzy" appearance.

Indian Cottons. These are the produce of various species, amongst which *G. herbaceum* is the most important. The seeds have a short fuzz in addition to the longer hairs.

Sea Island Cotton. The most valuable of all cottons, owing to the comparatively great length (about two inches) of the fibre, and its silky character. The seeds bear long hairs only, and are left quite clean and smooth when these are pulled off. Sea Island cotton is often considered to be



Photo by Putnam and Valentine

COTTON ON THE WHARF AT NEW ORLEANS



By permission of Messrs. Newton & Co.

THE COTTON PLANT

a native of the West Indies, but was introduced to the Sea Islands (off the coast of Georgia and South Carolina), where it is largely cultivated and whence it derives its common name. Recently it has been reintroduced into the West Indies.

Egyptian Cottons, the more important of which are Mitafifi, Ashmouni, Yannovitch, etc., are varieties of this same species.

Kidney Cotton. The peculiar name of this variety is derived from the circumstance that the seeds in each of the three divisions of the boll remain firmly attached together forming a lobed, more or less kidney-shaped mass, instead of each being separate as in the other varieties. This species yields Pernambuco, Ceâra, and other kinds of South American cottons.

Tree Cotton. The produce of *G. arboreum*, which attains a height of from fourteen to twenty feet. Africa appears to be its native home, although it is grown to some extent in India.

The different varieties of cotton demand to some degree different methods of cultivation. Moreover, cotton is grown in purely tropical countries such as the West Indies, Africa, India, etc., on the inundated lands of the Nile valley, and in the United States, where the plants are annually cut down by frost. In some regions primitive labour and appliances alone are available; in others, such as the States, the highest scientific and technical skill are to hand. All these reasons necessarily entail differences in the mode of procedure, but, as it would not be possible to describe all the variations practised in the space of a few pages, attention must be restricted to summarising the principal features of cotton cultivation, and the gathering and preparation of the crop until it is packed up into the huge bales so familiar a sight in the neighbourhood of the docks of Liverpool, the great cotton-receiving port of England.

Cultivation

The cotton seed is sown and the young plants thinned out to the distance apart best suited to local conditions. In about six months' time they flower, and the pods or bolls follow in due course. When ripe they burst, often displaying their white cottony contents. Picking is done by hand, care being taken to harvest the cotton with as little as possible of such extraneous material as pieces of pods, twigs, dry leaves, etc.

The crop gathered is "seed-cotton," consisting of the seeds with the fibre or lint firmly attached. In primitive countries the lint is pulled off by hand. Usually, however, a gin is employed. One type of gin has rollers between which the lint passes, whilst the seeds remain behind. There are also the saw gins, in which the lint is pulled off the seeds by a rapidly rotating toothed disc or "saw." As the result of ginning lint is obtained and also the cotton seed. The latter may be used on the estate or as a source of oil. The lint is made up into bales, compressed, and is then ready for shipment.

DRUGS

In the present article an attempt is made to describe some of the more important vegetable products employed by man to alleviate the physical suffering of himself and of the animals which tend to his welfare. Strictly speaking, the term "drugs" includes all substances belonging to the animal, vegetable, and inorganic kingdoms, which have been so employed, but in the space at our disposal it has been impossible to deal even briefly with any but the most important of those derived from plants.

INDIAN HEMP. This important drug is obtained from *Cannabis sativa*, a plant indigenous to India and Persia, but largely cultivated in temperate parts of the world for the sake of the valuable fibre (hemp) and oil seed (hempseed). When grown in the hot regions of the tropics, the plants (especially the female plants) yield a quantity of resin possessing remarkable intoxicating properties, and on this account hemp is largely grown by the natives of India and the East. The drug appears in several forms in the Indian bazaars, the well-known "*ganjah*" being the leafy flowering branches of the plant trodden and pressed by the feet into compact masses; it is known in the English drug markets as "*guaza*." *Ganjah* is smoked like tobacco, but "*bhang*," prepared from the dried larger leaves which are collected separately, is pounded in water to a pulp and used in the preparation of a drink. The resin itself, to which the intoxicating properties of the drug are due, is known as "*churras*" or "*charas*," and is obtained either by kneading *ganjah* with the hands, or by causing men, clothed in leather garments, to brush through the living plants as violently as possible, with the result that the resin escapes from the wounded surfaces of the plants and adheres to the leather, from which it is afterwards scraped and rolled into balls.

In the home market the drug generally occurs as rough, flattened resinous masses composed of the flowering shoots compacted by pressure. It possesses little taste, but has a powerful odour, and is chiefly used for its soothing properties in cases of mania and hysteria.

RHUBARB. An important source of this valuable drug is probably *Rheum officinale*, a plant found wild in Eastern Thibet and North-western China, and now cultivated in England and elsewhere. The drug, which has long been known in Europe, consists of the dried rhizome



JAVA. GOVERNMENT QUININE PLANTATION



or underground stem of the plant, either whole or cut into pieces of suitable length. Th "roots" are dug up, cut transversely into short pieces which are threaded on a string, an dried in the sun or by artificial heat. Such pieces are known in the trade as "rounds," bu when too large the Chinese cut them longitudinally into two portions which are known a "flats." Rhubarb is obtained from China, and the various names of "Turkey," "Russian, and "East Indian" rhubarb are merely relics of former times when the root reached Europ from China *viâ* the countries mentioned. Small quantities of the drug are prepared i England from *R. officinale*, and, to a less extent, from *R. rhaponticum*. English rhubarb is excellent quality, and closely resembles the Chinese product. The drug contains sever constituents possessing laxative properties, and is used as a purgative and bitter toni The well-known grittiness of the drug is due to crystals of calcium oxalate.



DRYING AND PACKING QUININE

Podophyllum Rhizome. The underground stem of *Podophyllum peltatum* is the sour of *podophyllin* largely used as an emetic and purgative. The plant is a native of the easte states of North America and Canada, and was long known to the Indians as a valuable medicin As imported, the drug consists of flattened portions of the rhizome, possessing a heavy narcot odour and a bitter nauseous taste. The active principle is a resinous compound (*podophylli* which is precipitated from an alcoholic extract of the "root" by acidulated water.

The rhizome of *P. Emodi*, a common plant on the lower slopes of the Himalayas, h recently been proposed as a substitute for the officinal drug.

Aconite Root. The poisonous properties of the roots of the Aconite or Monkshoo (*Aconitum Napellus*) have long been known, but it is only in comparatively recent tim that the drug has been employed medicinally. The root alone is now officinal, but the leav and flowering shoots were also formerly used. The Monkshood is commonly grown in Englan both for ornamental purposes and as a medicinal plant; on the lower slopes of the Pyrenee the Alps, and the mountains of Germany and Austria, the plant is very common, and extensively collected by the peasants for sale in the drug markets. In England the drug collected in the autumn soon after the stem and leaves have died down, and before they ha



DRYING QUININE



FOUNDING A QUININE PLANTATION

begun to be depleted of their starch by the growth of new shoots, for it is at this stage that the proportion of alkaloid is generally regarded to be greatest. After the removal of the rootlets the roots are washed and dried, either whole or in longitudinal slices. The most important constituent of Aconite root is the alkaloid *aconitine*, which is used externally for certain forms of neuralgia and rheumatism. It is also used internally in cases of fever and for relieving pain, its general effect being to lower the temperature, increase the amount of urine, and to lessen sensibility. Japanese Aconite (*A. Fischeri*) and Indian aconite (*A. ferox*) are imported into this country and contain alkaloids very similar to those of the officinal drug.

IPECACUANHA ROOT. This drug, which has long been known in Brazil as a remedy for dysentery, consists of the thickened roots of *Psychotria Ipecacuanha*, a shrub growing in the shady forests of South America. Most of the supplies come from Brazil, but more or less successful attempts have been made to cultivate the plant in other parts of the world, notably in the East Indies. The slender roots, as they appear on the market, are about a quarter of an inch thick, breaking with a short fracture. The bark is markedly constricted at short intervals, and contains a large amount of starch.

Ipecacuanha is largely used in dysentery, and is a powerful emetic and expectorant; the principal constituents are the two alkaloids *emetine* and *cephaëline*. Besides the officinal drug, several varieties and substitutes are imported. New Granada and Carthagena Ipecacuanha is less active than the true root, and its botanical origin is uncertain. White or Undulated Ipecacuanha (*Richardsonia scabra*), False Brazilian (*Ionidium Ipecacuanha*), and other roots are substitutes of little, if any, medicinal value.

JALAP. The ovoid tuberous roots which arise from the runners of *Ipomœa Purga* are

well known on account of their valuable purgative properties. The drug is obtained from Mexico, where the plant is indigenous, the natives collecting the tubers and drying them in nets over their hut fires: the smaller roots are dried whole, but the larger ones are gashed with a knife in order to facilitate the process. The plant is found on the eastern slopes of the Mexican Andes, but it has been introduced into India and Jamaica where it thrives exceedingly well, yielding tubers which are particularly rich in the resin to which the activity of the drug is due. *Tampico Jalap*, distinguished from true Jalap by its irregular shape and shrunken appearance, is obtained from *I. simulans*, a plant also a native of the Mexican Andes.

Belladonna Leaves. The fresh leaves and branches of *Atropa Belladonna* (Deadly Nightshade) are used in the preparation of extract of belladonna, a drug largely employed as an external application to relieve pain, and internally for checking excessive perspiration in consumption, for the relief of coughs, and for many other purposes. The extract prepared from the leaves causes the pupil of the eye to dilate, and is used in ophthalmic surgery. The principal constituents of the leaves are two alkaloids, *atropine* and *hyoscyamine*, but in the manufacture of these alkaloids the root of the plant is employed.

Belladonna is largely cultivated in Germany for medicinal purposes, and, to a smaller extent in Bedfordshire and Hertfordshire. The leaves are collected during the flowering period, as at this time the percentage of alkaloid is highest.



YOUNG PLANTATION OF CINCHONA SUCCIRUBRA



ALEXANDRIAN SENNA LEAVES
(Natural size)

COCA LEAVES. "Folio Cocae" of pharmacy, are the dried leave of *Erythroxylum Coca*, a shrub about six or eight feet high bearing small clusters of white flowers and resembling in general habit the English blackthorn. It is chiefly cultivated on the steep slopes of valleys in the Andes, and smaller quantities are grown in other parts of the world, *e.g.*, India, Ceylon, and Java; the market is chiefly supplied from South America. Two varieties are met with in commerce, viz., Huanuco, or Bolivian, and Truxillo, or Peruvian. The former leaves have a brownish-green colour with prominent veins and are not broken to any great extent; they further possess a well-marked ridge above the mid-rib. In the Truxillo leaves this ridge is absent, and the fragile broken leaves are pale green. Coca leaves possess a somewhat bitter taste and have a slight but characteristic odour. They contain several alkaloids, the most important being *cocaine*, largely used in dentistry and in minor operations as a "local" anæsthetic, *e.g.*, a substance producing insensibility to pain over the immediate area to which it is applied. The proportion of the alkaloid present is less than one per cent., and the Bolivian leaves are richer than the Peruvian variety. Coca is also used as a restorative and stimulant, but its most remarkable property is that of conferring remarkable powers of resisting physical and mental fatigue. Comparatively but a small proportion of the coca leaves collected in South America is exported, the bulk of the crop being used by the Indians for the purposes mentioned. The custom is one of great antiquity, and the dried leaves have become almost indispensable to the people. The leaves are chewed, mixed with lime and the ash of a plant closely related to the goosefoots of our fields and waste places. When taken in excess the drug is said to produce an intoxication similar to that of opium in its effects, and slaves to the coca-habit seldom attain to old age.

SENNA LEAVES are obtained from two species of Cassia, a genus belonging to the *Leguminosae* (Pea family). "Alexandrian senna" consists of the leaflets of *Cassia acutifolia*, a small bush growing wild in several districts of Egypt. The leaves are collected by the Arabs chiefly between Suakim and Kassala, the most important of the two harvests taking place after the rains in September. The plants are cut and then spread out in the sun to dry, when the leaflets are removed from their stalks. The drug is then packed in palm-leaf bags and carried down for export either to the Red Sea ports or down the Nile to Alexandria. At one time the trade in senna was a monopoly of the Egyptian Government.

Indian or Tinnevelly Senna consists of the leaflets of *Cassia angustifolia*, which is abundant in Southern Arabia. The plant is largely cultivated for medicinal purposes in the Tinnevelly district of Southern India, whence the drug receives its name. The leaflets closely resemble Alexandrian senna, but are larger, somewhat narrower, of a lighter green colour, and less hairy; an interesting difference between the drugs as they appear on the market is the flatter condition of Tinnevelly senna leaves, due to the fact that the leaves are pressed into bales before being shipped, whereas the Arabs pack the drug comparatively loosely.

Both varieties of senna are extensively used as a purgative in the form of an infusion and as an ingredient of "confection of senna."

COLOCYNTH or BITTER APPLE. The spongy, intensely bitter pulp of the dried fruit of *Citrullus Colocynthis*, a creeping plant belonging to the Cucumber family, is largely used as a powerful purgative. The plant is regarded as a native of the warmer districts of Asia, but it is now widely distributed, occurring abundantly in Egypt and Northern Africa; it is also common on the shores of Portugal and is found in Syria, Persia, and India. The fruits, which resemble an orange in shape and size, are green when fresh, but become yellowish-brown when

dried. They are collected when ripe and the thin rind removed with a sharp knife, leaving the white pulp containing a large number of seeds. The drug consists of white balls about two inches in diameter, and generally more or less broken. They are extremely light in weight, and the seeds themselves constitute about three-quarters of the total weight. The "Turkey" and "Spanish" colocynth are the principal varieties met with, and the former commands the highest prices, though there is no reason to suppose that it possesses more active properties. The action of colocynth is due to an intensely bitter substance, *colocynthin*, occurring only in the pulp which alone is used in medicine. "Mogador" colocynths, from which the rind has not been removed, are also imported, and are commonly used by druggists for show purposes in window-dressing.

Nux Vomica. The seeds of *Strychnos Nux-vomica* have long been known as a valuable drug, though for some time after their introduction into Europe in the sixteenth century they were chiefly used as a poison for dogs, cats, and vermin. The tree is a native of the Coromandel Coast of India and Cochin China, and is also found in Ceylon and North Australia. The fruit closely resembles an orange, and contains usually from three to five seeds embedded in a bitter whitish pulp. The grey, disc-shaped seeds, which are closely covered with fine silky hairs, are about the size of a halfpenny, and somewhat thinner at the centre than at the circumference. They are extracted from the pulp, and then washed and finally dried in the sun. They are exported chiefly from India, the chief ports being Madras, Bombay, Calcutta, and Cochin. The dry seeds possess an intensely bitter taste and are very hard. They are extremely poisonous on account of the presence of two alkaloids, *strychnine* and *brucine*. The drug is extensively used in small doses as a valuable tonic and in the treatment of certain forms of paralysis and other nervous diseases. In large doses it is a virulent poison.

Cola or Kola Nuts. These nuts, also known as Bissy or Gooroo Nuts, have long been highly prized by the natives of tropical Africa and elsewhere on account of their stimulating and sustaining properties when chewed. The white or crimson nuts occur five to fifteen together in large woody fruits; they are deprived of their seed-coats and masticated while fresh. There are two varieties of Cola nuts on the market, viz., the kernels of *Cola acuminata* and *C. vera*. The former nuts possess four cotyledons, while the latter, which are the most valuable, possess only two. The most important constituent of the drug is an alkaloid, *caffeine* (also found in coffee), and a small amount of *theobromine* is present. It is to these substances, chiefly the former, that the drug owes its stimulating properties which cause it to be used in medicine to prevent fatigue and as a nerve stimulant.



ALOES

Areca or Betel Nuts. Areca or Betel Nuts are the seeds of *Areca Catechu*, a palm largely cultivated in India, Ceylon, and Malaya. The "nuts" are enclosed in the outer fibrous shell of the fruit, which resembles an egg in size and shape. They are bluntly conical, about an inch long, and, in section, exhibit a mottled appearance, the white endosperm being traversed by wavy, dark-brown lines which are due to ingrowths of the seed coat.

The nuts are used in this country for destroying worms in dogs, but by far their most important

use is in the East, where they are in universal demand among the natives as a masticatory or chewing material. For this purpose the nuts are cut into thin, narrow slices, which are rolled up with lime in leaves of the betel pepper (*Piper Betle*). The mixture has a hot and acrid taste when chewed, and its immediate effect is to increase the flow of saliva, which is turned a brilliant red colour. The teeth of the consumer are also stained, but there are said to be no evil results of the habit, which is so firmly established among the natives "that they would rather forego meat and drink than their favourite areca nuts." The importance of the trade in the nuts may be judged from the fact that, in Ceylon alone, the export trade in 1905 was valued at considerably over £100,000 sterling.

BARKS AND WOODS.

CINCHONA BARK is the source of the invaluable alkaloid *quinine*, so largely used in the treatment of fevers. The medicinal value of the bark first became definitely known in 1638, when the Countess Chinchon, wife of the Viceroy of Peru, was cured of fever by use of an extract of the bark, and it was not long before the drug became recognised in Europe as a valuable febrifuge. Cinchona bark is obtained from several species of Cinchona, a genus of trees belonging to the Rubiaceae found truly wild only in South America, but now extensively cultivated in Java, India, Ceylon, and, to a smaller extent, in the West Indies and tropical Africa, whence the drug is now chiefly obtained.



BELLADONNA
Showing leaves in unequal pairs (reduced)

The commercial supplies of the drug are obtained from the following species of Cinchona, the first three of which are the most important:—*C. Ledgeriana*, *C. Calisaya*, *C. officinalis*, and *C. succirubra*. The method of collecting the bark which is becoming generally adopted at the present time is known as "uprooting." As the name indicates, the trees, as soon as they have reached the period of growth when the bark contains the maximum amount of quinine, are grubbed up, and the bark stripped from the trunk, branches, and roots, the root bark being especially rich in the alkaloid. The land is then replanted. A method which has met with considerable success in India consists in removing the bark in alternate longitudinal strips and covering the wounds with damp moss or litter in order to allow a new bark to develop on the exposed surface. Analysis shows that the secondary bark is richer in quinine than the "natural" bark, and is, therefore, of greater commercial value. A third method, known as the "shaving," is a modification of that just mentioned, and consists in removing only the outer part of the bark by shaving with a tool, so that the "renewed" bark may be formed without the necessity of binding damp moss round the tree. The South American method, as stated above, is to fell the tree and strip off all the bark, subsequently drying it in the sun or over fires. The larger pieces are pressed under heavy weights and constitute the "flat bark" of the trade, while the thinner bark of the smaller branches is known as "quilled bark" on account of its rolling up into quills when drying. The finer qualities of quills are obtained from the young branches which arise from the crowns of plants which have been coppiced.

The principal constituents of Cinchona bark are alkaloids, of which the chief are *quinine*, *cinchonidine*, *cinchonine*, and *quinidine*. The value of a bark is estimated according to the quantity of quinine present, the average amount varying from 3·0 per cent. to 5·0 per cent. in "Ledger" bark (*C. Ledgeriana*), from 3·0 per cent. to 4·0 per cent. in Calisaya bark (*C. Calisaya*). Quinine is chiefly used in the treatment of fevers, and as a tonic: the barks are too bulky for general use, except as bitter stomachics and tonics. The drug has a well-known intensely bitter taste, but a form is now prepared which is tasteless.

It would be difficult to over-estimate the value of quinine to the white man in guarding against and withstanding the attacks of fever, especially malaria, in the tropics. As an instance of its recognised value it may be mentioned that the Indian Government has ordered that the drug, put up into small pice packets, shall be on sale at every post-office throughout the country, so that the remedy may be within the reach of all, even the poorest.

Cascara Sagrada. Cascara Sagrada ("sacred bark") is a valuable medicine used in small doses as a tonic, and in larger quantities as an aperient and purgative. It is the bark of *Rhamnus Purshiana* (a small tree closely allied to the English Buckthorn), which is found in abundance in certain of the United States of America. The bark occurs in commerce in the form of quills and flat portions, which are removed from the tree in the spring and summer, especially after a spell of rainy weather. The inner surface of the bark is of a reddish-brown colour, while the outer surface is frequently covered with lichens.

The chemistry of Cascara Sagrada is by no means well known, but the principal constituents appear to be *emodin*, *frangulin*, and *purshianin*, which possess purgative properties. The drug has a slight odour but a very bitter taste, and is in such demand that the cutting of the trees has recently been restricted by law in order to avoid extermination.

Guaiacum Wood. The heart-wood of *Guaiacum officinale* and *G. sanctum* contains a dark-coloured resin used in the preparation of a tincture employed in the treatment of gout and rheumatism. The wood itself is an ingredient in the compound decoction of sarsaparilla used in the treatment of syphilis. The drug is principally obtained from *G. officinale* ("lignum vitæ" of commerce), an evergreen tree occurring in the West Indies and South America; supplies are principally obtained from Cuba and Hayti. The vessels and other elements of the heart-wood are filled with a dark resin which, when exposed to the action of oxidising agents, assumes a blue colour.

Quassia Wood. The wood of *Quassia amara*, a tree native to South America, first became used in medicine about 1750. Later it was found that the wood of *Picraena excelsa* possessed almost identical



THE KOLA TREE

properties, and in England has been adopted as officinal in place of Quassia which is still retained on the Continent.

Picraena excelsa is a tree of medium size common in the lower country of Jamaica. The wood is entirely without odour, but possesses an intensely bitter taste. The chips and shavings of the wood are used in the preparation of a bitter tonic.

EXTRACTS

OPIUM. This drug, so well known, even in remote times, for its valuable sedative properties, is the dried milky juice or latex obtained from the walls of the unripe seed capsules of several varieties of *Papaver somniferum*, the Opium Poppy. The narcotic properties are due to the presence of certain alkaloids, the most important being *morphine*, and, to a less extent, *narcotine* and *codeine*. Opium is prepared chiefly in Turkey, India, Persia, and China, but excellent qualities have been obtained from European experimental plantations, notably in France; the cost of production, however, renders the preparation of the drug in Europe commercially impossible. As is well known, the industry is of great importance in India, where, except in the Native States, it is under strict Government control.

The method of collecting the latex is practically the same in all countries. While the capsules are still unripe, incisions are made in their walls with a small instrument so constructed that it is impossible to penetrate to the seeds, which would prevent them ripening and thus spoil them as a source of oil. (See "Oils and Fats.") The latex immediately exudes and soon begins to coagulate. Next morning it is scraped off with a knife and the damp pinkish mass placed in sloping dishes to drain. When this is completed, the opium is allowed to partially dry in the sun, when it is ready for packing.

The high price of the drug naturally results in its frequent adulteration. Besides seeds, charcoal, and ground poppy petals, such crude adulterants as sloe, sand, mud, and pieces of metal are sometimes added to increase the weight.

The bulk of the opium reaching this country is imported from Persia and Turkey. As is well known, practically all the Indian drug exported goes to China, but the latter country imports large quantities overland from Persia, and in recent years has made great strides in the home production of the drug. The universal use of opium as a narcotic in China needs no more than passing mention.

ALOES. Aloes is the dried juice of the leaves of certain species of Aloe, a genus of plants belonging to the Lily family, and indigenous to South and East Africa, but now introduced into the West Indies and other tropical countries. The four principal varieties of the drug are "Curaçoa aloes" (commonly known as "Barbados aloes"), obtained from the leaves of *Aloe chinensis*; "Socotrine aloes," obtained from *A. Perryi*, in the island of Socotra, and the east coast of Africa, whence it reaches this country *viâ* Bombay; "Cape aloes" and "Natal aloes," obtained from several South African species of Aloe, one of which is probably *A. ferox*.

A large proportion of the supplies of the drug come from the Dutch West Indies, chiefly Curaçoa. The juicy leaves are cut from the plant and immediately placed with their cut ends downwards in sloping troughs placed at convenient intervals on the field or plantation. The juice rapidly exudes and is collected in gourds or tin boxes through an aperture at the lower end of the trough. It is then taken to the boiling house and evaporated in copper pans until it becomes a thick, black, viscid mass. When of the right consistency, the aloes is poured into gourds or boxes where it cools and solidifies.



JALAP ROOT

On some estates, the evaporation is effected by steam-heaters. As stated above, Curaçoa aloes is frequently described as "Barbados aloes" from the fact that in the early part of last century the bulk of the drug from the West Indies came from the British island. The trade, however, has almost disappeared, and at the present day the drug is produced on only one estate. The plant cultivated is *A. vera*.



ALOES

The famous Socotrin aloes is prepared by much cruder methods. The juice is collected in goatskins placed in shallow hollows scooped out in the ground, and allowed to partially evaporate in the sun. It reaches this country as a pasty or even semi-fluid mass which is dried at a gentle heat before use. Cape and Natal aloes is prepared in a way similar to that adopted in the West Indies.

The appearance of the drug when it reaches the market is largely dependent upon the methods employed in its preparation. When the juice is rapidly concentrated and quickly cooled, the mass breaks with a glassy or vitreous fracture as in Cape and Curaçoa aloes ("glassy" aloes). When evaporated slowly the mass becomes dull and opaque, and is known as "livery" or "hepatic" aloes, as in the case of the drug from Socotra, Zanzibar, Natal, and, in some cases, from Curaçoa.

Aloes is used as a purgative, and is one of the most valuable of this class of drugs. Its action is due to the presence of the crystalline, bitter principle *aloin*.

GUMS AND RESINS

BALSAMS, BALSAMIC RESINS, AND GUM-RESINS

THESE products are usually of little commercial importance, and they are almost wholly used in medicine. The most important of the balsams and balsamic resins are storax, benzoin, the balsams of Tolu and Peru, and Dragon's blood (obtained from the fruits of a rattan palm (*Calamus draco*) growing in Sumatra and Borneo, and used chiefly as a red stain for spirit varnishes. The best known gum-resins are myrrh, olibanum or frankincense, galbanum, asafœtida, and ammoniacum. Many drugs are used for the sake of the resins they contain, these not being exuded by the plant but secreted in roots, leaves, etc., from which they must be extracted by chemical processes.

GUMS

The term *gum* is loosely applied in commerce to a number of different products, which are better classified into the following groups:—1. *True gums*, such as Acacia gum, Tragacanth gum, etc. 2. *Varnish resins*, such as "Gum dammar," "gum copal," etc. 3. *Balsamic resins*, such as "Gum benjamin or benzoin," etc. 4. *Gum-resins*, mixtures of gum and resin, such as "gum myrrh," "gum asafœtida," etc. 5. *Dried plant juices*, such as "Gum opium" and "gum kino."

The true gums, which alone will be dealt with in this article, are readily distinguished from the products included in classes 2 to 5, and wrongly called gums, by the possession of the following characteristic properties:—1. They are soluble in water, yielding clear viscid or jelly-like solutions. 2. They are insoluble in alcohol. 3. They are almost tasteless, or have at most either a slightly acid or slightly sweetish taste.

NATURE OF GUMS

The process by which true gums are produced in plants is not as yet thoroughly known. They appear to be formed by the progressive breaking down (gummosis) of cellulose, but practically nothing is known as to how this "breaking down" is accomplished.

GUM ARABIC

This is a generic name including practically all gums, which are soluble in water to form



Photo by T. G. Hall, Esq., F.L.S.

PINE TREES

viscous sticky solutions possessing the properties of ordinary "office gum." Gums of this type are largely produced in the Anglo-Egyptian Sudan, Abyssinia, Somaliland, Nigeria, Senegal, India, Australia, and Cape Colony.

Turkey or Sudan Gum

This material is produced in the several countries forming the North-eastern horn of Africa. It has been an article of commerce from very early times; there is evidence that as early as the first century of the Christian era gum was shipped from Egypt to Arabian ports and thence sent to Europe, hence the designation "gum arabic" now loosely applied to all gums of this type. In the Middle Ages the trade in gum between Egypt and Europe was carried on *viâ* Turkish ports and hence the name "Turkey gum" still in use, though the trade *viâ* Turkey has long since ceased. This fact is slowly being recognised by a change in name, and the gum is now frequently referred to commercially as "Sudan or Kordofan gum."



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GATHERING CRUDE TURPENTINE, NORTH CAROLINA

Three kinds of gum are largely produced in the Anglo-Egyptian Sudan, and these are known in the country as "Hashab" or "Verek," "Gezira," and "Talh" gums.

Hashab. The "Hashab" tree of the Sudan is known scientifically as *Acacia Senegal*. It is plentiful in Kordofan, where the best qualities of this gum are produced, and is also fairly widely distributed in Kassala and Gezira. The gum produced in Kordofan is collected from trees grown in plantations known as "geneinas." These trees are raised from seed and



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DISTILLING TURPENTINE, NORTH CAROLINA

begin to exude gum in the third year of growth, when they are from eight to ten feet high, and have a maximum girth of from six to eight inches. They continue to produce gum until the fifteenth year, when it is advisable to renew them. The best yields are obtained from the eighth to the twelfth years of growth.

"Hashab Wady" is the name applied to gum which is exuded naturally from "hashab" trees not included in the "genena," and is usually in pear-shaped pieces of variable size depending on the length of time between consecutive pickings.

Most of the gum exported is merely cleaned, but a small quantity is "selected" and "specially dried." For this purpose nearly colourless "tears" are selected from the crude "hashab" and exposed on the sand along the banks of the Nile to the sun. After a few days of this treatment they become white and almost opaque, due to the production of innumerable cracks as the result of the drying. This gum fetches a higher price than the crude mixed material.

For most purposes to which gum is applied in commerce, the crude unselected "hashab" is suitable, but for a few purposes "graded" or "selected" gum is required. The "selection" of gum is principally done in European centres of trade, such as Trieste, London, and Hamburg.

Senegal Gum.

The "hashab" tree (*Acacia Senegal*), from which Sudanese gum is principally derived, occurs right through the fertile belt of territory (the Central and Western Sudan), which stretches across Africa below the Sahara. On the north bank of the Senegal vast forests of *Acacia Senegal* occur stretching away into the hinterland. This region is inhabited by Moors and other wandering peoples who employ their slaves and probably also their prisoners of war in the collection of gum. No system of cultivation such as that adopted in the "genenas" of Kordofan is attempted in Senegambia or its hinterland. During the rains the forests are converted into swamps and the trees become gorged with sap. After the rains have ceased the scorching east wind known as the Harmattan prevails, and this rapidly removes the excess of water; the barks of the trees become fissured in all directions and through these fissures the gum exudes as a thick liquid, which rapidly dries into "tears."

Wattle Gums

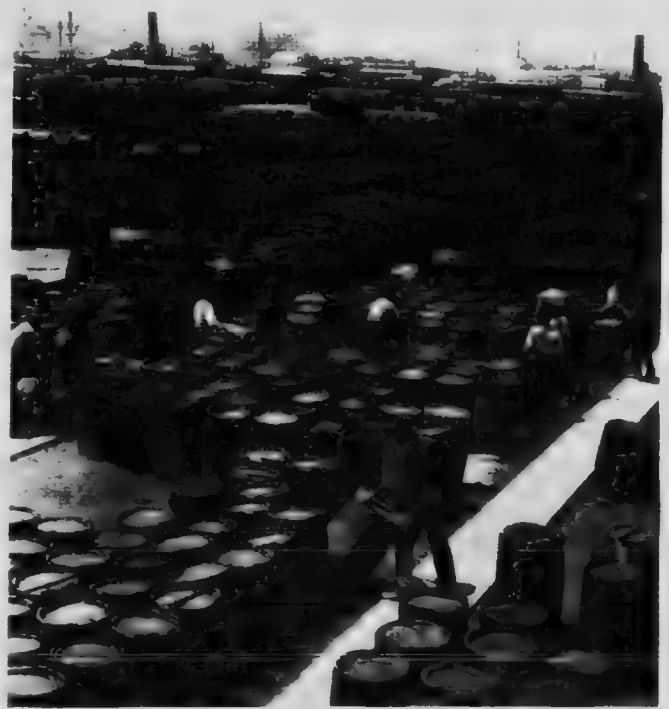
The wattles are a group of acacias indigenous to Australia, where they are largely exploited for their barks, which are rich in tannin (see p. 352), and for their soluble gums. Several of the wattles have been introduced into South Africa, where they are cultivated for bark, gum being collected from them as a bye-product. The principal Australian species yielding gum in notable quantities is *Acacia decalbata*. Cape gum is obtained from *Acacia horrida*.

Indian Gums

Two varieties of gum are exported from India, viz., "East Indian gum," already alluded to, which consists essentially of Somaliland gum mixed with true Indian gums, and Ghàti gum, so named because it is collected spasmodically by the natives inhabiting the western Ghats. The Ghàti gum which reaches this country is tolerably uniform and is probably collected principally from *Anogeissus latifolia*. It is usually of pale colour and possesses special properties, which have secured for it a prominent place as a substitute for Sudanese and Senegal gums, especially in the United Kingdom.

RESINS

The commercially valuable resins are, as explained in the article dealing with gums, known in commerce as gums, *e.g.*, "gum copal," "gum dammar." They are readily distinguishable from true gums by being soluble in spirit or oils, but not in water. They also differ from gums in their mode of formation in plants thus, whilst true gums are apparently *decomposition* products of cellulose, resins appear to be *elaborated* by plants from certain constituents of the essential oils. It follows from this mode of formation that resins usually occur in plants associated with essential oils, thus "common rosin" occurs in special ducts in pine trees dissolved in oil of turpentine, and similarly fresh copal and dammar usually contain small quantities of the essential oils from which they were probably originally formed. The resins of commerce may conveniently be divided into four classes:—
1. *Varnish resins.* These are usually hard substances containing either no essential oil or very small quantities of such volatile products. Examples: copal, dammar, sandarac, mastic. 2. *Oleo-resins.*



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THE RESIN MARKET, SAVANNAH, GEORGIA



By permission of the New Zealand Government

A KAURI TREE

Mixtures of essential oil and resin. These are usually viscous liquids or semi-solids. Examples: "Balsam of Copaiba," wood oil, elemi, Canada balsam. 3. *Balsams and balsamic resins.* These may be either liquids such as "balsam of Peru" or solids such as "benzoin." They contain either benzoic or cinnamic acid, and the presence of one or both of these acids or their compounds confers on them their peculiar "balsamic" odour. These true "balsams" should be distinguished from such products as copaiba and Canada "balsams," which are really oleo-resins. 4. *Gum-resins.* These are mixtures of true gums with resins and may also contain some essential oil. Examples: Myrrh and asafoetida.

Copals

The copals are a class of hard resins used in the preparation of elastic varnishes suitable for outdoor use, as for example, on railway carriages.

They are derived from many different trees and are procured from several countries. They are always very hard, melt with difficulty, are usually insoluble in all solvents and are only convertible into varnishes by a preliminary process of destructive distillation.

In all the localities in which copal is produced, three qualities are generally put on the market:—1. *Fossil Copal*, found in the ground usually in districts from which copal trees have entirely disappeared. 2. *Semi-fossilised Copal*, collected from the soil in the neighbourhood of living copal trees. 3. *Fresh Copal*, found on living trees either as the result of exudation through natural fissures or from artificial incisions. Of these three kinds the first is of most value, "fresh copal" being of little value in European markets.

East African Copals. These are also known in English commerce as "animi resins or gums." They are found in a fossil condition in Zanzibar, Madagascar, and along the East African coast from the third to the tenth parallel of latitude.

American Copals. These are collected in South America and probably originated from *Hymenaea Courbaril*, a tree closely related to that supposed to have produced the East African copals, which they resemble in character, though they are somewhat softer.

Kauri or *Coaric Copal.* This variety is produced wholly in New Zealand, whence enormous

quantities have been exported during the last sixty years. The resin originally exuded from the Kauri pine (*Dammara Australis*), forests of which still exist in New Zealand from which "fresh kauri" is collected to a small extent.

Oleo-Resins

Turpentines. By "turpentine" is usually understood in this country the familiar colourless liquid used for many domestic purposes. This product is more accurately called "oil of turpentine" since it is produced by the distillation of the crude "turpentine," which exudes from pine trees. "Turpentine" is chiefly obtained from *Pinus australis* in the United States, *Pinus pinaster* (*maritima*) in the Gironde district of France, and *Pinus sylvestris* in Russia. In the United States preparations for the collection of "turpentine" are made in winter. Three pocket-like cavities, each capable of holding about a quart, are cut in the trees at a distance of 6 to 12 inches above the ground. The "turpentine" which exudes from incisions periodically made in the tree accumulates in these cavities, and is ladled out from time to time by the collectors. Some of the turpentine dries on the trees; this is scraped off and forms the material known in commerce as "common frankincense." The "turpentine" is then transported to central factories for distillation, the distillate being "oil of turpentine" and the residue "common rosin" or "colophony."

TANS AND DYES

The operation of "tanning" consists in the conversion of hides and skins into leather. This change is effected by the use of certain vegetable products called tanning-materials, which contain a peculiar compound known as *tannin*, having the property of combining with the substance of hide and skin forming leather, thereby converting a material which readily decays into one which is proverbially resistant.

Nature of Tanning Materials

Tannin occurs in all parts of plants, but it appears to be most secreted in those portions which are of relatively little use to the plant as a living agent, viz., the



HEMLOCK SPRUCE



OAK TREE

bark of the stem or root, the rind or husk of the fruit, or the heart-wood, though in a few cases it occurs in large quantities in the living parts of plants, *e.g.*, in the leaves and roots.

As a general rule a part of a plant is unsuitable for use as a tanning agent unless it contains at least ten per cent. of tannin, though this alone is not sufficient to give a material value for this purpose; it must in addition contain non-tannin extractive matter, which is useful in producing what tanners call a "well-filled" leather. It must further be free from dark or undesirable colouring matters, as otherwise the value of the leather produced will be prejudiced by its colour, which should be at most a pale russet-brown. Though it is not customary to use tanning agents containing less than ten per cent. of tannin, a method has been devised for the utilisation of such materials as oak-wood and chestnut-wood, which contain only three or four per cent. This consists in extracting from these the whole of the soluble matter they contain and concentrating this extract till it solidifies. In this way "tanning extracts" containing as much as thirty per cent. of tannin may be obtained from oak-wood.

This process, first devised in order to facilitate the exploitation of materials poor in tannin, has, during the last few years, been greatly extended until at the present time practically all important tanning materials can be bought in the form of extracts. At first the manufacture of these was confined to the industrial countries in which leather manufacture was principally carried on, but lately the tendency has grown to make these extracts where the tanning-materials are produced. In this way the exporter pays transport charges only on the material actually used by the tanner and can use the inert matter left after extraction as fuel and in other ways.

Tanning Materials derived from Oaks

Oak Bark. This was at one time practically the only tanning material used in the United Kingdom for heavy leathers, but of recent years its use, though still very large, has become more restricted owing to the fact that the bark is expensive as a tanning agent and cannot compete in price with many materials of exotic origin now available. Oak bark is a bye-product of the oak timber industry, and is only collected from felled trees. The trees are usually cut down from April to June, and the bark is at once detached, roughly cleaned from lichens, moss, etc., and dried. It is sold either in pieces about a yard long ("long rind bark"), or is chopped into small pieces ("hatched bark"). English oak bark contains from twelve to fifteen per cent. of tannin, and is richest when collected from trees from thirteen to twenty-five years old. A good deal of oak bark is also obtained from Belgium, Holland, France, and Sweden, the Belgian being considered the best of these imported varieties.

Oak-wood. The heart-wood of the common oak contains from two to five per cent. of tannin, and is therefore unsuitable for use in the crude state. The sawdust, shavings, and waste pieces are, however, utilised, as already described, for the manufacture of "oak-wood extract,"

which contains from twenty-six to thirty per cent. of tannin. This is principally made in Hungary and Italy.

Galls. These are excrescences produced on the gall oak (*Quercus tinctoria*) as the result of punctures made by the "gall insect." They contain forty to fifty per cent. of tannin, and are used principally in the manufacture of ink.

Valonia. This consists of the acorn cups of the valonia oak (*Quercus aegilops*), which occurs widely distributed in Asia Minor and the Balkan Peninsula. The cups are picked by hand after the acorns have fallen and are simply dried in the sun.

Valonia contains from twenty-five to thirty per cent. of tannin, and is used for the production of sole leather, for which purpose it has largely replaced oak bark in the United Kingdom.

Tanning Materials obtained from Coniferous Trees

A considerable number of coniferous trees yield barks suitable for use in tanning. In Scotland the bark of the larch (*Larix Europaea*) is employed: it contains about nine per cent. of tannin, and is valued particularly for light leathers. Throughout Austria the bark of the Norwegian spruce is commonly made use of; it contains about eleven per cent. of tannin, and yields a plump, nicely coloured, but rather poorly filled leather. Considerable quantities of tanning extract are now made from spruce bark in Austria for export. The same spruce grows commonly in the United Kingdom and in Scandinavia, but, curiously enough, in spite of the large supplies of the bark which must be available in Norway and Sweden, it is but little used in those countries.

"*Hemlock Bark.*" This is obtained from the "hemlock" fir (*Abies canadensis*), a tree widely distributed in Canada and throughout the northern part of the United States, in which countries it forms the staple tanning material. The bark contains from seven to ten per cent. of tannin, and yields a plump, rather reddish leather. Hemlock bark is a bye-product of the timber industry, and as disafforestation is rapidly proceeding in the United States, the bark is becoming scarce. There are, however, large forests of hemlock fir in Canada, and there the bark is used in the local tanneries, but probably a much larger quantity is converted into "hemlock extract," which is imported into European countries and the United States. The Canadian extract contains from twenty-eight to thirty per cent. of tannin.

Birch Barks

These are also products which are fairly extensively used in several countries, but are too poor in tannin to be worth export. White birch bark (*Betula alba*) is collected and used to a small extent in Scotland and is employed on a considerable scale in Russia. The bark contains about ten per cent. of tannin and in addition a small quantity of a pleasant-smelling volatile oil, which is absorbed by hide. It is to the presence of this oil that the characteristic fragrant odour of "Russia" leather is due.



OAK APPLE GALLS

Birch bark produces a soft light-coloured leather specially suitable for the "uppers" of boots and shoes.

Chestnut Bark and Wood

The bark of the common chestnut (*Castanea vulgaris*) contains practically as much tannin as oak bark, but is rarely used for tanning purposes. The green wood contains from three to four per cent. of tannin, and, like oak-wood, is employed as a source of extract in France, Italy, and Austro-Hungary, where it is available in large quantities.

"Chestnut extract" contains from thirty to forty per cent. of tannin, and furnishes a firm, tolerably heavy, but rather grayish leather, which darkens somewhat when kept. It is imported principally from Italy and Austro-Hungary, and largely used in the United Kingdom as one of the ingredients of a mixture employed in tanning sole leather.



WATTLE

Willow Barks

These are obtained as bye-products in the cultivation of willows to be used for basket-making. They are employed more especially in Denmark, Belgium, Holland, and France for tanning leather intended for the manufacture of gloves and similar articles. The barks of *Salix arenaria* and *Salix Russeliana* are most sought after for this purpose. They contain from eight to twelve per cent. of tannin, and yield a peculiarly soft, pliable, light-coloured leather.

Wattle Barks

These products, also known as mimosa barks, are obtained from a series of acacias indigenous to the southern parts of Australia, and now largely cultivated in Natal. The best Australian species are the "broad-leaved" or "golden" wattle of South Australia (*Acacia pycnantha*), the bark of which may contain as much as forty to fifty per cent. of tannin; the "golden" wattle of New South Wales (*A. longifolia*) yielding bark containing twenty to twenty-five per cent. of tannin, *A. mollissima* (*A. decurrens*) and *A. dealbata* with barks containing from thirty-six to thirty-nine per cent. of tannin.

Little attention has been paid in Australia to the cultivation of wattles, but in Natal it is done on a large scale, the species *A. mollissima* and *A. dealbata* being those most commonly grown. The seed is sown in May at distances of about twelve inches in furrows six to eight feet apart. When the young plants are well established they are thinned out to about six feet apart. Very little care, except weeding, is then required by the plantation until the plants are about three feet high, when the lower branches should be pruned off so that a straight even trunk from which the bark can be easily detached may be grown. Bark may be collected from the time the trees are five years old but the richest is obtained when they are about ten to twelve years old. It is collected in September or December in Natal, being then richest in tannin. After stripping it is merely dried in the sun, and either cut into small



CINCHONA. THE SOURCE OF QUININ

pieces or ground to a coarse powder. Wattle bark is largely used in the United Kingdom for tanning sole leather. It yields a firm, solid leather with a faint pink tint.

Divi-divi

This material consists of the dried husks of the pods of a leguminous tree, *Cæsalpinia coriaria*, indigenous to Central America and cultivated in South America, and, on a small scale, in Java, India, and Australia. In preparing it for the market the pods are split open, and the husks, which are similar to those of an ordinary pea pod are spread out in the sun until they become hard, brown, and dry.

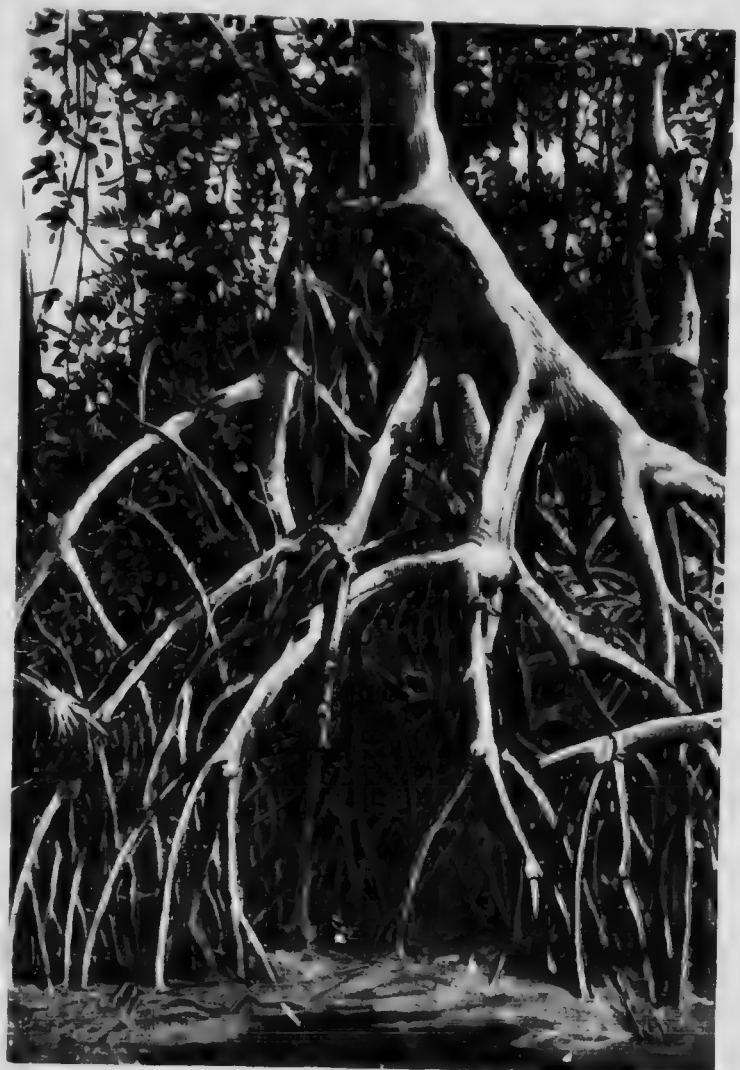


Photo by Sir Harry Johnston, K.C.M.G., K.C.B. By permission of Messrs. Hutchinson

MANGROVE SWAMP

Sumac

This well-known and valuable tanning material consists of the dried leaves of *Rhus coriaria*, a shrub cultivated in Sicily and growing wild in Austria and the Balkans. The plant thrives on sunny slopes of dry, stony, and barren soil; it is usually grown from shoots and develops rapidly. Plucking of the leaves may be commenced in the second, but preferably in the third year, and after fifteen years' growth the shrubs cease to yield leaves rich in tannin and should be replaced. The leaves are usually dried and ground several times in stone mills to produce a fine powder for export. Good Sicilian sumac contains from twenty-three to twenty-seven per cent. of tannin. Sumac is used for the production of soft, light-coloured, mild leathers, and is almost indispensable at present for tanning such materials. It is also very largely employed for improving the colour of leather tanned with cheaper, dark-coloured materials, such leather being usually given a final dressing in a hot sumac solution.



MANGROVE THICKET

Canaigre or "Tanner's Dock"

This product is one of the few roots used as a tanning material. The plant is a native of Mexico and the Southern parts of the United States, and is now extensively cultivated in those regions for the sake of its root. It is best grown from tubers, which should be planted out in the autumn, but may be also raised from seed. The roots are harvested in the second year, and are cut into slices, which are dried in the sun or made into "canaigre extract." Good canaigre may contain from twenty-six to thirty per cent. of tannin, and yields a firm heavy leather of a bright orange colour.

Quebracho

This material, which owes its name to its exceptional hardness, quebracho being a corruption of the Spanish word for "axe-breaker," consists of the wood of a South American tree, *Quebrachia* (*Loxopterygium*) *Lorentzii*. The tree is a fairly large one, and is grown on an enormous scale in the Argentine Republic. The wood contains about twenty per cent. of tannin, and yields a firm but rather reddish leather.

Myrabolans

This, one of the most important Indian tanning materials, especially for export purposes, consists of the unripe fruits of *Terminalia chebula* or *T. belerica*, trees which are common in India, especially in Madras and the Central Provinces. The fruits are collected when full grown but still unripe, and are prepared for the market merely by drying in the sun.

Gambier

This material is also known as "white catechu." It is an extract prepared from the leaves and branches of a climbing plant, *Uncaria gambier*, which grows in the East Indies, especially in Malaysia. For the production of gambier, the trees are cropped almost bare of twigs four times a year from the time when they are three years old, so long as they bear well. The twigs with the leaves are chopped small and extracted by being boiled with water in copper pans until a syrupy liquor is formed. This is strained and allowed to flow into tubs, in which it sets to a brownish-white, semi-crystalline solid, which while still soft is cut into approximately one-inch cubes.

Mangrove Bark

The mangroves are an interesting group of trees, which inhabit the swampy foreshores of tropical countries where they form forests frequently of vast extent. The barks of all the mangroves appear to contain more or less tannin, but the species, which has so far been

exploited principally are *Rhizophora mangle*, *Rhizophora mucronata*, and *Bruguiera gymnorhiza*, yielding barks containing from forty to fifty per cent. of tannin. The bark is merely stripped from the stems and branches, broken up into small pieces, and dried in the sun, preferably under cover. When dry it is packed into bales weighing about one cwt. The manufacture of mangrove tanning extract and "cutch" is carried on on a considerable scale in Borneo and some other East Indian islands.

Mallet Bark

This tanning material is derived from *Eucalyptus occidentalis*, and has been exported during the last few years on a large scale from South Australia. The bark, which is of medium thickness, is very hard and shows a cinnamon-brown colour; it contains as a rule from thirty-five to forty-five and occasionally up to fifty per cent. of a readily soluble, yellow-brown tannin, which yields a firm, tough, light-brown leather.

DYE-STUFFS

Dye-stuffs of vegetable origin have become almost a negligible quantity in the world's commerce since the introduction of the so-called "aniline dyes," and what was at one time an industry of great importance to many agricultural countries has now sunk to comparatively small proportions.

The vegetable dye-stuffs owe their characteristic colouring powers to the presence of small quantities of highly coloured substances (dyes) secreted by the plants. In general the "dyes" are not readily retained by fabrics unless the latter are first treated with a mordant. This consists in steeping the fabric in a solution of a weak salt of one of the metals iron, chromium, aluminium, or tin. The steeped fabric is then dried and treated with a current of steam whereby a fine layer of metallic oxide is formed all over it, *i.e.*, the fabric is "mordanted." If it is now placed in an infusion of the dye-stuff, the "dye" forms a coloured insoluble compound with the "mordant," which is resistant to light and cannot be washed out. The coloured compound formed with each metallic oxide used as a mordant is different, and by this means a considerable range of tints may be obtained from each dye-stuff.

Indigo

This blue dye-stuff is obtained from a number of indigo-bearing plants (*Indigofera tinctoria*, *I. arrecta*, etc.) cultivated in India, Java, and Natal. It does not occur naturally in the plants but is formed by a process of fermentation. Fresh plants, collected at the flowering period (late summer in India and Java), are thrown into large vats containing water, and are thoroughly broken up by means of sticks wielded by natives. By this means the soluble matter contained in the plant is dissolved out. The watery extract is drawn off into a second vat, where it is thoroughly churned up so as to expose it as much as possible to the air. This "churning" is accomplished in India usually by natives, who wade about in the vat and beat the liquid with sticks, though the more enterprising planters have adopted the Javanese method of agitation with a current of steam or compressed air. The



INDIGO



By permission of Messrs. Hutchinson

MANGROVE AND PANDANUS SWAMP

liquid changes in colour from yellow to blue owing to the gradual production of the dye-stuff, which separates as a fine powder. When the action is complete the indigo is allowed to settle to the bottom, the water is run off and the dye-stuff collected, and while still wet and pasty made into little cubes.

Indigo as produced from plants is by no means a pure material. It contains even under the best conditions only eighty per cent. of pure indigo, or as it is technically called *indigotin*. The impurities present are water, mineral matter, indigo-red, and other substances. The purest natural indigo is that produced in Java. Indian indigos rank next in quality.

Cutch

This material, also known as "black catechu," as distinguished from "white catechu," or gambier was formerly prepared almost entirely in India from the heart-wood of *Acacia catechu* or *Acacia suma*, but recently several of the East Indian islands and the European Protectorates on the East Coast of Africa have commenced the preparation of a similar product from mangrove bark, which is known as "mangrove cutch."

RED DYE-WOODS

Logwood

This material is the heart-wood of *Haematoxylon campeachianum*, a spreading tree of moderate size seldom exceeding forty feet in height, native to the Bay of Campeachy, Honduras, etc. It was introduced into Jamaica in 1715, and is now largely grown there. The principal producing countries in order of importance are Mexico, Hayti, San Domingo, Cuba, Honduras, Jamaica, and the smaller islands, Guadaloupe, St. Lucia, and Grenada.

Brazil Wood, Lima Wood, (Peach Wood) Sappan Wood

These materials, which all contain the same dye "brazilin" are derived from a number of species of *Caesalpinia*; thus Brazil wood is yielded by *C. crista* and *C. brevifolia*, and is obtained principally from Brazil, Mexico and Jamaica. Peach wood is derived from *C. echinata* in Mexico, and sappan wood from *C. sappan* which is found in China, Japan, and the East Indies. The wood is applied in dyeing and printing in the same way as logwood, being as a rule first converted into extracts.

Camwood, Barwood, and Red Sanders (or Sandal) Wood

These three red woods possess very similar tinctorial properties. Red sanders wood is derived from an Indian tree, *Pterocarpus santalinus*; barwood from a West African tree, *Baphia nitida*, common in Sierra Leone, and camwood is either identical with barwood or is from a closely related tree. They are usually imported as coarse powders produced by rasping.

YELLOW DYE-STUFFS

Old Fustic

This is obtained from *Morus tinctoria*, which occurs widely distributed in the East Indies, Central and Southern America, and the West Indies. The wood is hard, of a bright yellow colour, with a somewhat reddish tint, and comes into commerce in blocks weighing about one cwt. The best qualities come from Nicaragua, Cuba, and Jamaica, and medium kinds from Mexico and Venezuela. For dyeing purposes the wood is converted into extract by a process similar to that used with logwood. "Old fustic" contains two dyes, *morin* and *maclurin*. It is principally used by the dyer for leading blacks and browns as described under logwood



By permission of Messrs. W. Ransome's Sons, Hitchin

CUTTING PEPPERMINT

Other well-known yellow dye-stuffs are Persian Berries, the unripe berries of a species of *Rhamnus* growing in Southern Europe, The Levant, Asia Minor, and Persia; Quercitron Bark, from a species of oak indigenous to the United States; Weld; Turmeric, which is largely grown in India; and Annatto, so widely cultivated in tropical countries.

Archil, Cudbear, and Litmus

These three products are obtained from a number of different lichens imported from Ceylon and Mozambique, the most important being *Roccella tinctoria* and *Lecanoria tinctoria*, which possess the property of producing a violet-blue dye when exposed to the joint action of ammonia and air. For the preparation of archil the lichens are simply sprayed with a solution of ammonia and exposed to the air. When the dye is fully developed, the mass of lichens is extracted with water forming "archil liquor," or the latter may be evaporated to dryness forming "cudbear." If the treatment of the lichens with ammonia is long-continued and lime is eventually added to the mass before extraction with water, the purple dye "litmus" is obtained. This is usually sold mixed with chalk or powdered gypsum. Archil is used in wool and silk dyeing to produce purple colours. Litmus is used in chemistry for the detection of acids and alkalis; its natural purple tint is changed to vivid red by acids and to deep blue by alkalis.



GATHERING MINT

ESSENTIAL OILS

The descriptive term "volatile" serves to differentiate these products from the "fixed" oils, which do not evaporate on exposure to air. The older name "essential" indicates that they are "essences," *i.e.*, the constituents to which the plants containing them owe their peculiar properties, thus, the characteristic aroma and flavour of the well-known spice, cinnamon, are due to the essential oil it contains, and this oil, possessing in a far higher degree the aroma and taste characteristic of cinnamon can be extracted from the spice, leaving a material devoid of odour and flavour.

Volatile oils are usually prepared by a process of distillation in steam. For this purpose the material to be operated upon is ground, placed in a copper still, covered with water, and allowed to stand for some hours. The still is then heated so that the water boils, producing steam, which carries away in a state of vapour the volatile oil contained in the plant, and this mixture of steam and oil vapour passes into the condenser attached to the still, where it forms water with a layer of oil floating on it. When the whole of the available oil has been procured in this way it is skimmed off the water and filtered.

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CUTTING LAVENDER



By permission of Messrs. John Jakson & Co., West Croydon.

CUTTING LAVENDER

In some cases distillation cannot be resorted to as the application of heat destroys the valuable odorous constituents. Thus, in preparing lemon and similar oils obtained from the rinds of *Citrus* fruits a process of expression is made use of for the preparation of the best qualities, and only the poorest kinds are obtained by distillation. The fruit is cut into halves or quarters, and the adhering acid pulp removed. The portions of rind are then either squeezed against a sponge held in the right hand of the operator or in the case of halves are pressed against it and rotated. In this way the small cells in which the essential oil is secreted are broken, and as the oil exudes it is absorbed by the sponge. When the latter becomes saturated the oil is squeezed out into a receptacle. In the West Indies, where lime oil is made on a large scale, the portions of rind are drawn across upright brass needles fixed in the bottom of a bowl, or the whole fruit is gently rolled over the points. The oil cells are thus pricked by the needles, and the oil flows out and accumulates at the bottom of the bowl. These "expression" and "pricking" processes do not remove the whole of the oil from the rind and the rest may be obtained by steam distillation, the distilled products being of inferior quality and selling at lower prices.

When neither distillation nor "expression" processes are available, "enfleurage" methods are used, which consist in soaking the material in warm fat. From this the volatile oil is dissolved out by pure spirits of wine. This process is used in the preparation of perfumes.

The volatile oils are used as solvents, perfumes, flavouring agents, or drugs. It will be readily understood, therefore, that a considerable range of these products comes on the market; attention can, therefore, only be directed to the few, which are of the first importance.

Oil of Turpentine. The manufacture of this material has been described previously. It is produced chiefly in the United States, France, Russia, and Austria, and is employed principally as a solvent for resins in the preparation of oil varnishes, and as a vehicle for pigments in oil paints.

Volatile Oils used in Perfumery

"*Otto of Roses.*" This extremely valuable oil has been in use for centuries in the East as a perfume. It is produced for export almost exclusively at the present day in Bulgaria from the petals of *Rosa damascena*, and though considerable quantities are made in Persia, India, and elsewhere, these kinds do not come into European commerce. "Rose water" is made chiefly in the South of France by the distillation of the petals of the "cabbage rose" (*Rosa centifolia* with water; it consists of a solution of a small quantity of "otto" in water.

Geranium Oil. This material is obtained by distilling the leaves of certain species of pelargonium cultivated in Spain, France, Algeria, and Réunion.

Lemon Grass Oil. This is prepared in India from the grass of the same name (*Andropogon citratus*). It has an intense lemon odour and is used for perfuming soaps.

Lavender Oil. This is prepared by distillation from various lavender plants. In England *Lavandula vera* is cultivated largely in Surrey, Hertfordshire, Kent and Lincoln for this purpose.

Oils obtained from Citrus species. These include the important oils procured from such well-known fruits as the orange, lemon, lime and bergamot, all produced by citrus trees. These oils are made chiefly in Sicily and Calabria (Southern Italy), though some of them are also obtained from the South of France and the West Indies. They are, as already indicated, made by "expression" or "pricking" processes. The most important of them, as perfumery agents, are *orange oil* made from the rind of the sweet orange, *mandarin oil* prepared from the peel of the mandarin orange, *bergamot oil* extracted from the bergamot fruit rind, and *lime oil* made chiefly in Montserrat and other West Indian islands from limes.

Other oils of this species are *Neroli*, *Ylang ylang*, *Patchouli*, *Opopanax*, and *Bay*.

Oils used as Flavouring Agents

Lemon Oil. This is prepared principally in Sicily by the expression processes already described from the rind of the ordinary lemon. The chief centre of the trade is Messina.

Essential Oil of Almonds is obtained from bitter almonds by grinding these with water and steam-distilling. The crude product is submitted to a chemical process of purification to get rid of the poisonous prussic acid it contains.



GATHERING BELLADONNA



COCO-NUTS

Juniper Oil is prepared by steam-distilling the berries of the juniper tree (*Juniperus communis*), and is largely made in the United Kingdom, Germany, and Hungary. It is used to some extent in medicine, but principally as a flavouring agent for gin.

Wormwood Oil is procured by the distillation of the wormwood herb (*Artemisia absinthium*) and is made chiefly in the United States, France, Spain, and Algeria. The oil is the flavouring ingredient of "absinthe" liqueur.

A large number of other oils used as flavouring agents are obtained by the distillation of such well-known species as cinnamon, cassia, pimento (allspice), coriander, caraway, nutmeg, mace, cardamoms, spearmint, angelica, and cloves, and are applied much in the same way as the spices from which they are derived.

Volatile Oils used as Drugs

Camphor. This material is procured from the oil obtained by the distillation of the wood of the camphor tree, which grows in China and Japan, more especially in the island of Formosa. The tree has also been planted in Ceylon and Florida, and small quantities of camphor are now produced in both these localities.

Eucalyptus Oils. The large trade in eucalyptus oils is of comparatively recent growth, and is due almost entirely to the vogue these products have acquired as deodorants, antiseptics, and curative agents generally. They are obtained from various species of *Eucalyptus*, and are produced principally from indigenous trees in Australia and from trees grown in plantations in Algeria and the United States.

Peppermint Oil. This oil is obtained by the distillation of various species of peppermint, such as *Mentha piperita* and *Mentha arvensis*.

VEGETABLE OILS AND FATS

Under this title are included "fats" and "fixed oils." The distinction between "fats" and "fixed oils" is merely one of degree, as "fats" are reduced to an oily condition by heating. The "fixed oils" are entirely distinct from the "volatile" or "essential" oils. The latter differ in chemical composition, and can be distilled without undergoing change, while the fixed oils are decomposed before they pass off as vapour.

It will be convenient to consider the oils under the following headings:—(1) Drying Oils, (2) Semi-drying Oils, (3) Non-drying Oils, (4) Vegetable Fats or Tallows.

In the class of drying oils linseed stands pre-eminent, and except in one or two applications no oil can be utilised in its place as a drying oil. The other oils in this group are used locally

or without regard to their drying properties. In the class of semi-drying oils, cotton seed and the different rape oils are the most important. Among the non-drying oils olive occupies the first place, but ground or earth-nut oil is an important article of commerce. Palm oil is perhaps the most useful of the vegetable fats, while the fatty products of the coco-nut palm provide a valuable asset to the countries where the tree flourishes.

The methods of obtaining the oil from the seeds or fruits depend partly upon their size, hardness and other qualities, also upon the consistency of the oil and the use for which it is intended. There are two general methods adopted, (1) by expression, when the material is crushed in a press and the oil squeezed out: (2) by extraction, when the oil is dissolved out by suitable solvents. The different modes of pressing out the oil vary greatly from the primitive methods employed by natives of West Africa, India and elsewhere, to the modern extensive equipments of Europe and America, as described for cotton seed oil (see p. 368).

The machines employed for cleaning and preparing vary with the raw material, *e.g.*, cotton seed and earth nut require to be decorticated, linseed and rape-seed have to be screened and cleaned, coco-nuts are treated in a breaker or disintegrator.

Previous to pressing, large seeds or bulky material are first reduced in an edge-runner seed mill, consisting of two vertical stones revolving in a circular trough: the final grinding, or, in the case of small seeds, the only grinding, is performed in seed crushers. The crushers contain one or more series of rollers, that are grooved for breaking up palm kernels and ground nut, or smooth for the comminution of linseed or copra.

The material is delivered from the crushers as meal and passes at once, or after a preliminary heating, to the cake-moulding machine. The heating is carried out in large cylinders known as "kettles," through which steam pipes are led for warming the meal; besides rendering the oil more fluid, the heating helps to break up the oil-containing cells.

The cold or heated seed-meal is measured out automatically into press cloths, that are generally made of closely-woven cotton cloth encased in close horse-hair cloth, and receives a preliminary squeeze to mould the material. The moulds or "cakes" are next transferred to the press. The presses are the most important item in the installation, and vary very considerably, but are all worked by hydraulic power. In the open-plate process the cakes enclosed in the cloth covering are packed between press-plates of a flat or grooved pattern and piled in the press. Twelve or more cakes are pressed in one of these machines, and the oil exudes from the meal



Photo by H. Hamsom, Esq., F.L.S.

PALM OIL TREE



OLIVE TREES

running down the sides, or is collected in grooves on the press-plates, whence it runs away to tanks situated below the press. Generally the cake is pressed a second and often a third time: previous to each expression the cakes are broken up in a cake-breaking machine or ground in the edge runner mill.

As there is a danger of the cloths ripping, pan presses have been devised in which for the cloths are substituted circular iron boxes or pans. These are packed with meal, and between each there is inserted a circular plate with a conical edge. When subjected to pressure, the plates are forced down on the meal in the boxes, the oil escapes through holes in the inner lining of the boxes, and collects in a circular groove on the plates, whence it runs off to the tanks. These presses are closed and have the advantage that besides doing away with the cloths, the cakes are equally pressed throughout.

Having described the general method of expression, the process of extraction may be shortly explained. In extraction the solvents used are principally petroleum ether and carbon bisulphide. Petroleum ether is more dangerous on account of the greater inflammability of the vapour, but carbon bisulphide produces noxious and poisonous fumes.

The finely broken-up meal is put into a vessel that is closed down tightly and the ether or carbon bisulphide is introduced: after passing over the meal and taking up the oil, the solvent is transferred to a vessel heated by steam, and distilled off, leaving the oil below. The solvent is then condensed and returned to the storage cistern for further use. The oil, not being entirely free from solvent, is subjected to the action of direct steam or a water spray. The chief feature in the extraction process is to arrange a plant that will work continuously until the oil is ready to be removed.

The choice between expression and extraction depends greatly upon the use for which the oil or fat is required. For edible oils, such as olive, sesamé, earth-nut, expression is necessary; it is also advisable to express the oil when the cake is intended for feeding purposes. The danger of explosion is a deterrent to extraction, but, on the other hand, by extraction more oil can be obtained; further, it is freer from mucilage and other impurities and the meal does not so readily become rancid.

It is impossible within the space at disposal to enter into the methods of refining oils and fats.

DRYING OILS

Linseed Oil. Linseed is obtained from the flax plant (*Linum usitatissimum*), also extremely valuable on account of its fibre, which is manufactured into linen. Russia is the



CAMPHOR TREE



Photo by W. H. Johnson, Esq., F.L.S.

GOLD COAST. MILLER'S PALM NUT-CRACKING MACHINE AT WORK

only country from which both flax and linseed are produced on a commercial scale. In Europe the flax plant is grown chiefly for fibre. In other countries, notably in the United States, Argentine, Uruguay, and British India, which with Russia produce the bulk of the world's supply of linseed, the plant is grown almost exclusively for seed.

The most interesting difference in variety exists between white-seeded and red-seeded forms, as recognised in India, although the statement is made that plants raised from white seed in certain soils produce -by reversion—red seed. The quality of oil from the white seed is generally reckoned superior.

It is found advantageous to keep the seed for a few months before it is pressed for oil. Sifting, screening and grinding between rapidly-revolving rollers are necessary operations preliminary to pressing. Hot pressing is usually practised, although the best grades of linseed oil, serving occasionally, as in Russia, for edible purposes or for mixing with paint, are cold pressed. The mucilage contained in the seed-coats known as "foots" has to be separated from the expressed oil, this being effected by forcing the oil through filter presses. There is no objection to the extraction of oil from the seed, and in America naphtha has been used for the purpose. The linseed oil is run into percolators, holding about 1,000 bushels of seed, where it is flooded with naphtha; separation of the linseed oil and naphtha is produced in the ordinary way by distillation.

The colour of linseed oil varies from a light to a brownish-yellow. The oil possesses an acrid taste and smell, soon becomes rancid on exposure to the air, and has the property of taking up oxygen from the air and drying to an elastic skin. This drying property is considerably increased by heating the oil with certain metallic salts, *e.g.*, litharge, known as "driers," producing the so-called "boiled" linseed oil, although it is now known that a temperature of 65° C. is sufficient for the purpose. The principal uses of boiled linseed oil are for making paints and varnishes, in the preparation of printers' ink, and in the manufacture of linoleum.

The following drying oils are also commercial: -

Candle-nut Oil derives its name from the custom of the natives in the South Sea Islands, who fix the seeds on bamboo and burn them as candles. The tree (*Aleurites moluccana*) is widely diffused throughout the Polynesian Islands and thence northwards to the Malay Peninsula. The oil dries about as rapidly as linseed and is suitable for varnishes, also for making soft soap.

Tung or Wood Oil is a Chinese product obtained chiefly from the seeds of *Aleurites cordata*, a good-sized tree growing wild, and also planted along the roadsides in China and Japan.

The cold-pressed oil of a pale yellow colour is known as "White" tung oil, the hot pressed, much darker, as "Black" tung oil. In China and Japan the oil is used as a preservative for coating timber, as a lubricant, and for illuminating.

HEMP SEED OIL is prepared from the fruits of *Cannabis sativa*, a plant of the nettle order. It is grown in Russia and Germany, in North America, in Egypt and other parts of Africa, also in Central Asia. The supply of seed for oil is practically European. The freshly prepared oil is greenish-yellow, with a peculiar taste and smell.

WALNUT OIL is obtained from the kernels of the common Walnut tree, *Juglans regia*. The seeds give about forty to forty-five per cent. of oil. Walnut oil dries quicker than linseed, and is used as a medium for paints. Fresh cold-pressed oil is suitable for edible purposes.

MAW or POPPY OIL is derived from the seeds of the Opium Poppy, *Papaver somniferum*, a herbaceous annual cultivated in India, Persia, Asia Minor, and elsewhere for the sake of the opium extract. It is grown in the north of France and in Germany, where two varieties with black and white seeds are recognised: the white yields the better oil, and the black is said to give a better return. Some of the oil pressed in the north of France is used for mixing with artists' paints and is sun-bleached by exposure in shallow troughs; cold-pressed oil is also prepared as a table or cooking oil. The darker-coloured oil is used for burning or for conversion into soap.

SAFFLOWER OIL is obtained from the seeds of *Carthamus tinctorius*, a plant belonging to the order *Compositae*, and is cultivated in India, Egypt, and China.

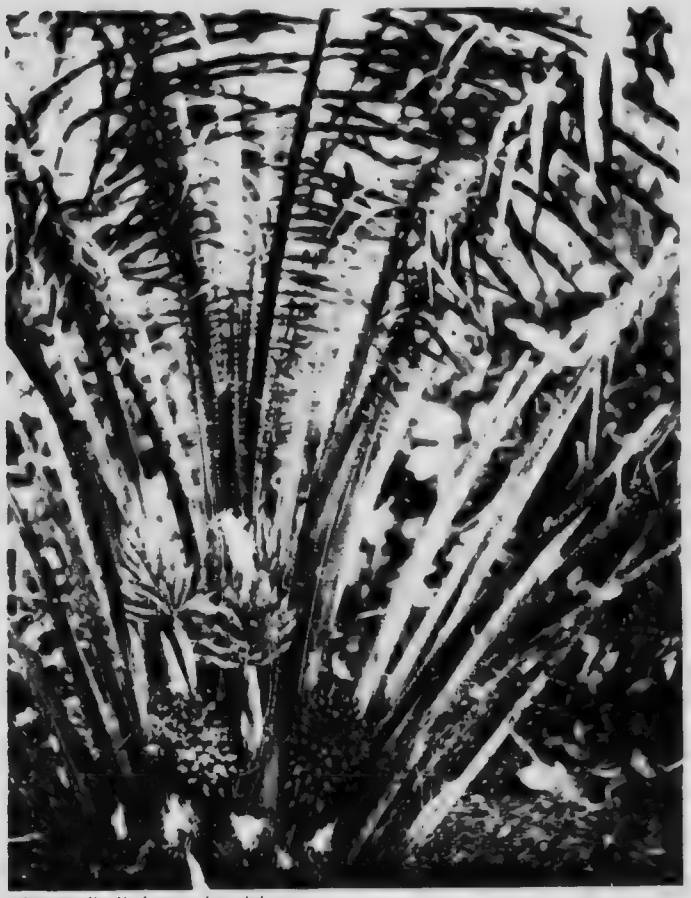


A WEST INDIAN PALM BEACH

The fruits, showing some resemblance to small sunflower seeds have a hard exterior, within which lie the seeds containing about thirty per cent. of oil.

NIGER SEED OIL is expressed from the fruits of *Guizotia abyssinica*, an annual plant belonging to the *Compositae* order. It is cultivated to a considerable extent in British India, where it was introduced from Abyssinia or Egypt.

SUNFLOWER OIL. The sunflower (*Helianthus annuus*) is an American plant, probably indigenous to Mexico, that has passed into universal cultivation for the sake of its flowers. As an economic plant it has received most attention in southern Russia.



OIL PALM

SEMI-DRYING OILS

COTTON SEED OIL is a good type of semi-drying oil, neither useful for mixing with paints or varnishes, nor suitable for lubrication. It has, however, come prominently into use as a salad or table oil, as a substitute for lard, and in the manufacture of oleo-margarine, while the cheaper qualities pass to the soap factory. To Americans must be given the credit of recognising the inherent capabilities of the oil, and this, combined with the very large quantity of cotton grown in the United States, has given that country a long lead in the production of cotton seed oil and allied products.

So much care has been bestowed in America on the treatment of cotton seed for the oil, hulls, and cake that an account of the processes furnishes a good instance of the intricate details of an oil mill. As the seed is ginned it is removed to the mills where storage accommodation on a large scale is provided. In the large factories as much as 200 tons of seed are pressed for oil in a day. Nearly all the work at these mills is performed mechanically. The seed having arrived at the mill is raised to the top of the store by bucket elevators into a screw "conveyor" that distributes it wherever available. As required, it drops into another distributor that transfers the seed to the revolving "boll-screen," a cylinder perforated with holes sufficiently large to let the seed pass through, while bolls, fragments of stalk, and other large impurities are retained. From the boll-screen the seed passes to another revolving perforated screen, in which the smaller impurities, dust and sand, are separated. After this the cleaned seed is



COPRA DRYING



Photo by Sir Harry Johnston, G.C.B., K.C.M.G. By permission of Messrs. Hutchinson & Co.

RAFIA VENIFERA PALMS

conveyed to the "linters," a type of saw-gin in which the saws are placed very close together, and here the short lint, that would otherwise soak up the oil, is removed. The next process is the shelling of the seed, which is performed in the "hullers," composed of an outer cylinder and an inner drum, in both of which knives are set. The rapidly-revolving knives break the shells and partly cut up the kernels or "meats." The mixture of hulls and meats is then conveyed to a revolving screen, through which the kernels pass while the hulls mostly remain behind, but a further separation is effected on an oscillating separator or "shaker." The hulls, owing to the persistent hairs, fall together in lumps and collect on top, while the meats fall through.

The kernels or meats are crushed between heavy iron rollers and then carried off to the heaters, steam-jacketed kettles, provided with stirrers to keep the temperature even. From the kettles the meats are taken to the "former," a machine that shapes the meats into cakes. The cakes, wrapped in hair cloths, are now packed into presses and subjected to a pressure of from 3,000 to 4,000 lbs. to the square inch. The oil is squeezed out and runs off, while the cakes are pressed as hard as boards. The oil is pumped into a settling tank, where the impurities gradually subside to the bottom and the clear oil is drawn off above. The settlings or "foots" are either passed through the press again or are sold for soap manufacture.

The oil-cake is, after the oil, the most important product obtained, and realises about one-fourth the price of oil. The value of oil-cake mixed with hulls as a food for fattening cattle has gradually been realised in the United States, but the bulk of the oil-cake is still exported.

SESAMUM or GINGELLY. The cultivation of *Sesamum indicum*, the plant yielding sesame oil, can be traced back to a remote antiquity. It is an erect growing herb somewhat similar to the Betony, with opposite leaves and yellow or pinkish flowers. The small flat seeds vary in colour from white to reddish-brown or black. The seeds contain about fifty per cent. of oil.

India is the largest grower of Sesamum, or, as it is there called, "gingelly," and while some of the seed is expressed in India, the bulk is shipped to Marseilles. Gingelly is a bland oil, nearly colourless and without smell. If carefully prepared it keeps sweet and is used in India for cooking purposes, for anointing the body, for illumination, and in the manufacture of soap.

Sesamum is also cultivated in Siam, China, and Asia Minor, where the seeds are used to flavour bread and cake. Palestine is said to produce the finest seed, which is exported from Jaffa. Marseilles is the great centre of the sesamum oil industry in Europe, but considerable shipments are made to Trieste and to German ports. In Europe the product of the first

expression forms a fine table oil that approaches most nearly to olive oil, for which it furnishes a substitute or adulterant.

Rape Oils. It is convenient to include under this head the oils obtained from the seeds of a number of plants belonging to the order *Cruciferae*. In the narrower acceptation of the word, the rape plant of Europe is *Brassica campestris*, var. *rapus*; but needless confusion is made in this country between the product of this plant and that of *Brassica campestris* which receives the name of colza oil in Germany, or *Brassica rapa*, to which the term "Rubsen oil" is applied. The seeds of these three plants are very similar in shape and in colour, but as a rule colza seeds are larger and yield a greater proportion of oil. Rape is cultivated in France, Belgium, North Germany, Austria, Roumania, and Russia. In Europe a distinction is made between summer rape that is sown in spring and matures in five months, and winter rape that is sown in autumn and reaped the following summer; winter rape is considered to yield better oil. The preparation of the seed for treatment consists in breaking down and crushing the seed, this being followed by pressing or extraction. The pressed cake is suitable for feeding cattle, the extracted cake is suitable for manure. Crude rape oil is dark-brown in colour, but is refined into a clear yellow oil that possesses a characteristic harsh taste.

Other semi-drying oils that find a commercial use are:

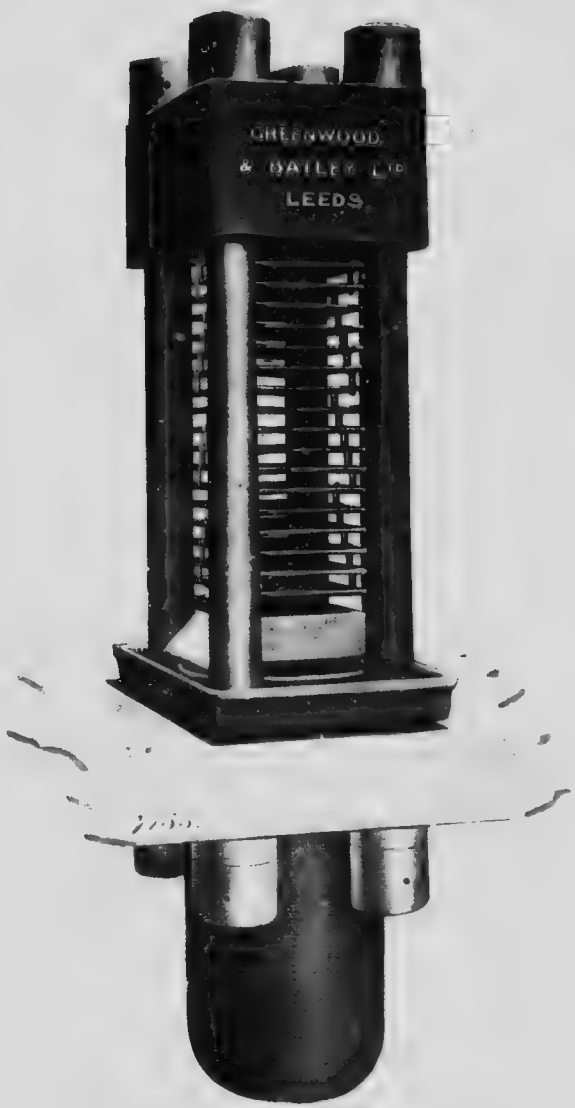
Kapok Oil, obtained from the seeds of *Eriodendron anfractuosum*, the Silk Cotton tree, cultivated for the "floss" that envelops the seeds. The oil, principally expressed from Java seed in Holland, approaches very closely in its properties to cotton seed oil; the better qualities serve for converting into butter substitutes, the poorer grades for soap-making.

Maize Oil is manufactured chiefly in the United States of America from the germs of the



Photo by W. H. Johnson, Esq., F.L.S.

PREPARING PALM OIL ON THE GOLD COAST



By permission of Messrs. Greenwood & Batley, Ltd.

ANGLO-AMERICAN HYDRAULIC OIL PRESS

maize grain (see pp. 51-2). These yield about thirty-five per cent. of a fairly thick, light yellow oil used for the same purposes as cotton seed oil.

NON-DRYING OILS

Olive Oil. The geographical distribution and characteristics of the olive tree (*Olea europaea*, have been described on p. 276. The olive flowers in North Africa, in Italy, and the South of Spain in March or April ; the fruits mature in about eight months, and the principal harvest falls in the months of December and January, or later. It is extremely important to gather the fruit when just ripe, as at this stage it contains the largest amount of oil. To obtain oil of the finest quality, not only should the olives be picked by hand, but the oil should be expressed within a day or two after picking. In addition to the oil contained in the fruit or pericarp, the seeds also contain a certain proportion of oil.

The fruits are generally crushed entire in an edge-runner mill or in a roller mill, although the finest oil is obtained by crushing the flesh alone, when the fruit is reduced to a pulp or "marc." The marc is packed in circular baskets made of esparto grass, or in bags bound with horsehair bands. A press is filled with a number of these baskets or sacks separated by wooden or metal perforated plates, that equalise the pressure, while allowing the oil to pass through. The presses are of various kinds, some being hand-lever or screw presses, while the larger ones are hydraulic. In any case the first pressure is a light one, as thereby a pure, clean oil is obtained, known as "Virgin Oil." The product of a second expression is also suitable for edible purposes. The marc is then broken up and mixed with hot water before the next expression, and subsequently a residue of oil is sometimes extracted with such solvents as carbon bisulphide or sulphuric ether.

The expressed oil is sprayed to get rid of the mechanical impurities and to precipitate any matter in suspension, after which it is run into cisterns to allow of further separation and

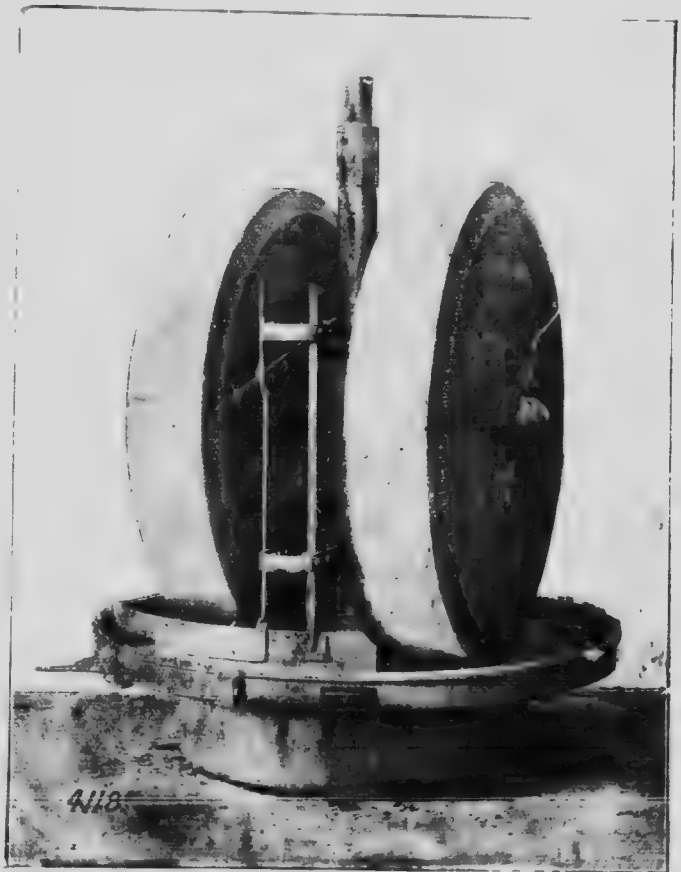
decantation. The fine sediment diffused through the oil falls to the bottom and the pure oil is drawn off from the top. It is still found necessary to filter the oil, and remove all traces of water before the oil is ready for consumption. Pure olive oil will keep for a long time, but when it is exposed to the air, if any water is present, fungi quickly develop and the oil turns rancid. The finest oil has a golden colour, tastes and smells slightly of the fruit, and is clear and limpid. Oil of a second quality is also designated "table oil." The oil subsequently obtained, known as "ordinary" or "common" oil, is thicker than the better quality oils, and has a yellowish or greenish tinge. Inferior grades are suitable for lubrication and for the manufacture of soap. The finest grades are supplied from the South of France and Italy. Spanish, Algerian and Tunisian oil are of inferior quality.

EARTH or GROUND NUT OIL. The leguminous plant (*Arachis hypogaea*), producing the fruit known by the names of earth nut, ground nut, monkey nut, and pindar, receives its name from the peculiar habit of ripening its fruit in the ground. There are two distinct types of the plant, the one with trailing stems that produces nuts from the flowers along the runners as well as near the root-stock, of which the Mauritius is a common example. The other type of plant is more erect and the nuts arise almost entirely from the base. The varieties from Brazil, Pondicherry, West Africa, and Madagascar come under this type.

The fruits consist of narrow straw-coloured, wrinkled pods. The seeds are covered with a thin white, reddish or purple skin; they have a slightly sweet nutty flavour and contain as much as thirty to fifty per cent. of oil.

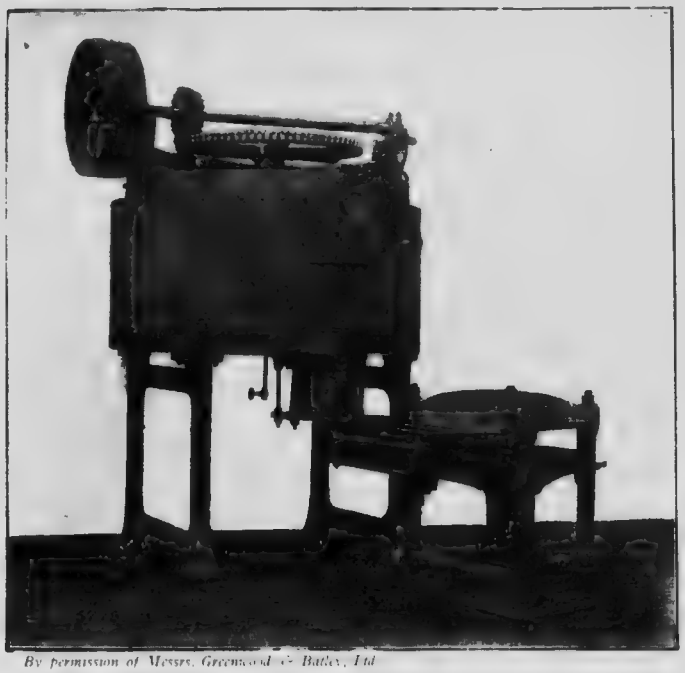
The cultivation of ground nuts is at present fairly world-wide. In South America they are grown in the Argentine, Brazil, and Costa Rica; they are extensively cultivated in the United States and eaten when parched. On the West Coast of Africa the crop is very important in Gambia and Senegal, and on the East Coast nuts are exported from Madagascar, Mozambique, and German East Africa. Pondicherry was formerly the centre of the Indian trade, but now the shipments from Madras are on a larger scale.

In Europe the expression of oil follows the usual course. The nuts, after being shelled, are cleaned by brushing and broken between rollers; they



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SELF-CONTAINED BELT-DRIVEN EDGE STONES



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SEED HEATING KETTLE AND HYDRAULIC CAKE-MOULDING MACHINE

are subjected to the blast of a fan to winnow out the skins and packed in cloths for the press. The oil is pressed out once or twice in the cold before the meal is heated. The cold-pressed oil is almost colourless, has an agreeable taste and smell, and serves as an edible oil. The oil obtained by hot expression is of a yellow colour and is used in the manufacture of soap. The residue is a valuable oil-cake that is used for cattle-feeding purposes.

TEA SEED OIL is a non-drying oil prepared in China and Japan, where it is used for cooking and for illumination, being derived from the seeds of *Camellia sasangua* or *Camellia oleifera*.

CASTOR OIL is obtained from the seeds of *Ricinus communis*, related to the Spurges, and most probably a native of North Africa, but now widely distributed throughout the tropics and the warmer temperate regions. It is cultivated in every continent, but the bulk of the world's supply is produced in India, about 70,000 tons of seed and nearly two million gallons of oil being annually available for export. In India a clear distinction is drawn between the commoner large-seeded variety and the small-seeded variety, the former sometimes grown as a perennial, the latter always treated as an annual.

For medicine, as is generally known, cold-drawn oil is preferred. The fresh seeds, sifted and cleaned from dust and *débris*, are crushed between rollers and packed in gunny cloth, when they are lightly pressed to take the suitable brick form. The bricks, separated by iron plates, are placed in a screw or hydraulic press, and the oil is collected in pans. Water is added to the expressed oil, and the liquid is boiled until the water has evaporated; by this means the albumen is solidified and the mucilage subsides to the bottom. The oil is then filtered and placed in cans for exportation. It has a light straw colour.

In addition to its value as a medicinal oil, castor oil was formerly used as an illuminant in India, but is now chiefly employed in the manufacture of Turkey-red oil, required in the dyeing and printing of cotton goods. The alizarine dyes, originally extracted from madder root, but now prepared synthetically, require to be dissolved in a neutral fat or oil, which besides dissolving the dye, must also penetrate the fabric. By treating castor oil with sulphuric acid a suitable solvent is found that receives the name of Turkey-red oil. Formerly olive oil was employed for the purpose, but it has been almost entirely replaced by castor oil.

VEGETABLE FATS OR TALLOWS

PALM OIL and PALM-KERNEL OIL. The well-known Oil Palm of the West Coast of Africa (*Elaeis guineensis*) furnishes two different oils—a bright yellow or red-coloured substance of a fatty consistence, palm oil, obtained from the fleshy outer covering of the fruits, and a white oil yielded by the kernels of the seed.

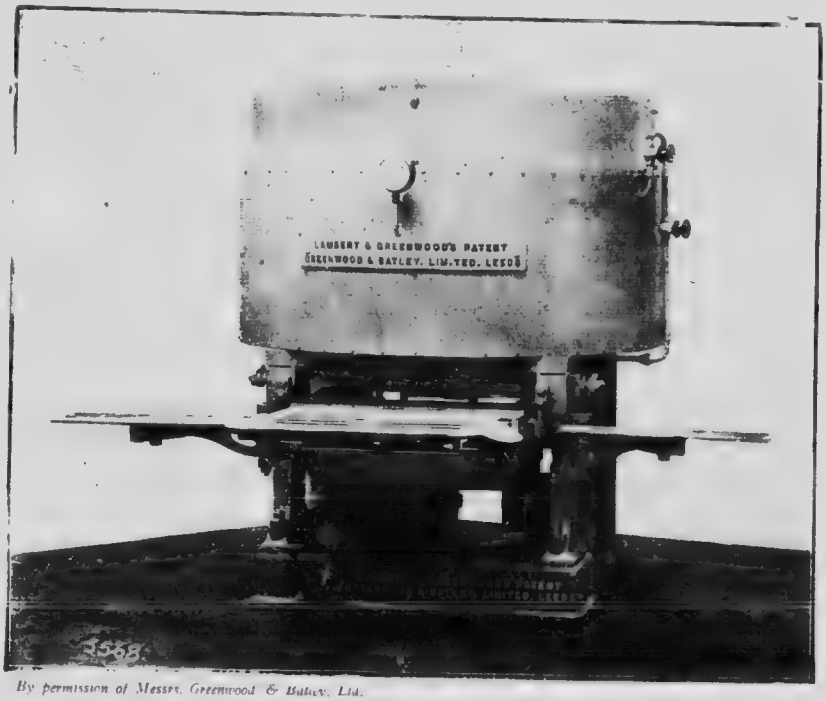
The Oil Palm has a wide geographical range in West Africa, from the Gulf of Guinea to the south of Fernando Po. It flourishes in the islands of Zanzibar and Pemba, and along the shores of the Central African lakes; also, supplies have lately been exported from the Philippine Islands. The palm reaches a height of thirty or more feet, and bears large "heads," each containing several hundred fruits. The fruits have a fleshy and fibrous outer layer of a bright orange-yellow or orange-red colour; under this covering is a nut with a very hard shell, which encloses the kernel.

The preparation of palm oil is undertaken by the natives in the countries where the palm grows. To collect the fruits the native climbs up the palm and cuts off the fruit heads.

The fruits, after a time, separate from the heads, are cleaned and put into iron or earthenware pots partially filled with water and boiled until they form an oily mass. This is transferred to a wooden trough, where it is left overnight to cool. At daybreak next morning, water having been added, men get into the trough and pound the oil out of the mass by treading it with their feet. The oil gradually rises to the surface and is skimmed off by women, who pass it through a sieve to remove the coarser impurities. It is then poured into a pot and boiled until the yellow-red oil rises to the surface (see p. 371). The oil is heated again to drive off any traces of water.

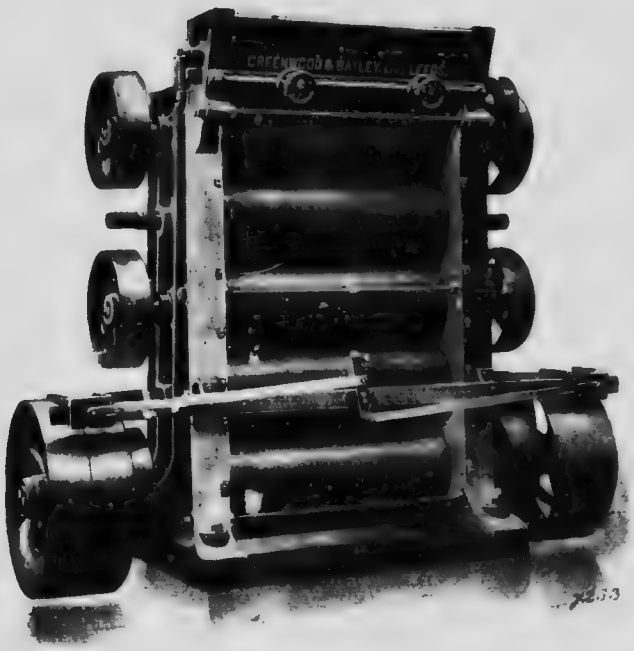
Palm oil varies in colour ranging through all shades from orange-yellow in the "Lagos" varieties to a dirty red in the "Congo" oils. It has a somewhat sweetish taste and a characteristic odour. When fresh, it is a good edible fat and is extensively used as such by the natives, who greatly enjoy "palm oil chop," and to some extent by Europeans living in the country. Its chief commercial use in Europe is for the manufacture of soap and candles, and very large quantities are annually imported for this purpose. Another important application of the product is in the tin-plate industry, in which large quantities of "palm oil greases" are used for covering the surfaces of the iron plates to prevent oxidation previous to the tinning process.

The oil obtained from the kernels of the nuts is known in the trade under the names of "Palm Nut Oil" and "Palm Kernel Oil." The nuts or "stones" freed from their oily fleshy outer layer are collected during the manufacture of palm oil, and the native women and children crack



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SELF-ACTING CAKE MOULDING MACHINE AND SEED HEATING KETTLE



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ANGLO-AMERICAN SEED-CRUSHING ROLLS

the nuts singly between two stones. The shells are thrown aside and the "palm kernels" collected either for the preparation of the oil or for export to Europe.

The bulk of the kernel oil used in Europe is prepared from imported kernels. The latter are screened to remove impurities and ground between rollers. The oil is expressed in hydraulic presses or extracted by the action of solvents, the expressed cake being used as a cattle food. Palm-kernel oil is white in colour, and in the fresh state has a pleasant smell and an agreeable nutty flavour.

Coco-nut Oil. The Coco-nut Palm is the most useful and at the same time one of the most ornamental trees of the tropics. Ceylon is and has been for some time the principal producing country, and in addition to the very numerous small properties owned by natives, extensive groves have been planted by Europeans since 1841. In India the presidency of Madras is the chief centre of production, notably along the Malabar and Coromandel Coasts. The native state of Travancore, with which Cochin is associated, exports copra, coco-nut oil, coir, and nuts. The tree flourishes also in Malaya and the Philippines. Coco-nut trees yield the most valuable production of the South Sea Islands, all the export being in the form of copra. From East Africa, the Seychelles, and Mauritius, in addition to the local consumption there is an export of copra and oil. In the West Indies and Brazil the palm is largely cultivated to furnish the demand for nuts that exists in the United States: Trinidad and Jamaica both export coco-nuts.

The roughly triangular fruit, about the size of a man's head, is covered with a thick fibrous husk which yields coir (see p. 324), and within, a hard shell encloses one seed. The oil is obtained from the kernel of the ripe nuts, and may be expressed locally, or the kernel is cut into portions and dried, when it receives the name of copra (see p. 369).

There are a large number of other vegetable fats or tallows that regularly or occasionally arrive on European markets. It is only possible to mention a few of these.

Carapa Fat is a thick and colourless fat, melting about 24° C., that is derived from the seeds of species of Carapa, belonging to the order *Meliaceae*. *Carapa guyanensis*, a lofty tree, grows in Brazil, Guiana and on the West Coast of Africa; *Carapa moluccensis* is found on the coasts of India, Ceylon, and the Moluccas. The kernels yield from fifty to sixty per cent. of fat which is expressed in France and the United Kingdom for use in soap-making.

Mahua Butter is derived from the seeds of *Bassia latifolia*, the "Mahua" tree of India, of the order *Sapotaceae*, grown widely in Central India. In Southern India *Bassia longifolia* takes its place. The seeds contain about fifty per cent. of fat.

PHULWARA BUTTER is the produce of an allied tree (*Bassia butyracea*), known as the Indian "Butter" tree.

SHEA BUTTER is obtained from the seeds of *Butyrospermum Parkii*, a large tree, allied to the Bassias, widely diffused through northern tropical Africa. The seeds yield about fifty per cent. of fat, having at ordinary temperatures a buttery consistency: it is greyish in colour, and when fresh has a pleasant taste and smell. The seeds imported into Europe pass to candle and soap factories.

SPICES AND CONDIMENTS

A LARGE number of vegetable products, although of themselves of little or no nutritive value, have been used by man from the earliest times to render ordinary articles of food more palatable. Such substances are known as spices and condiments, and, in addition to merely improving the flavour of the food, in a large number of cases they act as digestives, since, in coming into contact with the membranes of the digestive tract, they cause an increased secretion of the digestive fluids.

Many condiments, such as salt, vinegar, and artificial compounds do not come within the scope of this article, which deals with the more important of the spices and condiments derived from plants.



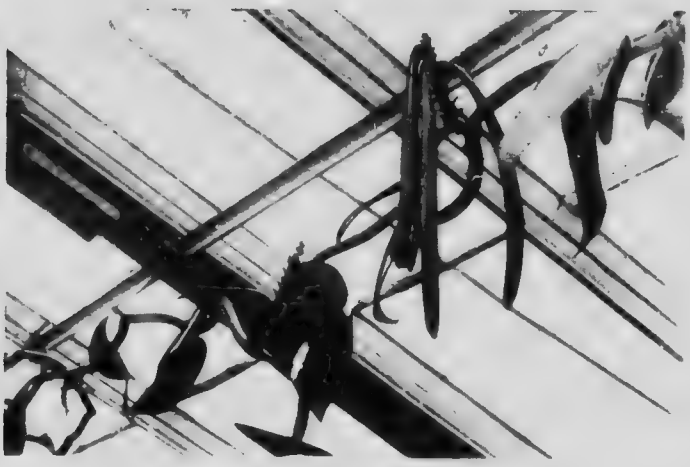
PIMENTO OR ALLSPICE

VANILLA

This well-known spice consists of the cured pods of one or more species of Vanilla, a genus of Orchidaceous plants, native to South America. The bulk of the vanilla of commerce is the product of *Vanilla planifolia*, a climbing plant indigenous to Mexico, but now cultivated in several parts of the tropics, notably in Java, Seychelles, Mauritius, and Ceylon.

The methods of culture and preparation vary somewhat in different parts of the world, and the system adopted in Seychelles will be described.

Vanilla was introduced into these islands in 1866, probably from Réunion. The vines are trained over small trees, or on hardwood stakes connected at the top by crosspieces; the most satisfactory method is to allow each plant a separate tree over which to climb. The supporting trees are planted about nine feet apart, those already standing on the estate being utilised as far as possible. The vanilla cuttings are planted at the foot of the trees, covered with a mulch of dead leaves and grass, and the free ends tied to the tree by strips of the leaf of the Screw Pine (*Pandanus utilis*). Their rapid growth soon enables the shoots to be trained through the forks of the branches to which they attach themselves by tendrils. At the end of eighteen months the plants are pruned in order to induce the formation of flowers on easily accessible branches. The checked branches, generally from four to six feet long, now hang down to within about a foot from the ground, and it is upon these branches that the flowers are chiefly formed. The fully developed pods are only formed after the flowers have been fertilised, and, in a state of nature, this very seldom happens



A VANILLA VINE

owing to the peculiar form of the stigma rendering the transference of pollen a matter of great difficulty. On an estate, therefore, "pollination" is effected artificially by hand, the pollen being placed upon the stigma by means of a finely-pointed piece of bamboo. The flowers are not all pollinated, the actual number depending upon the size and condition of the vine. Generally speaking, about thirty pods per vine are allowed to mature, the flowers on the lower part and sides of the cluster being chosen, since they yield the best and most shapely pods. The pods reach their full size in about six weeks, and, when ripe turn slightly yellow. They are then picked from the vine, great care being exercised to avoid splitting or cracking the pods which would at once rank them as inferior grades.

Before the pods are ready for the market as vanilla they are subjected to a curing process, during which their characteristic odour is developed. The aroma and flavour are chiefly due to the presence of a substance known as *vanillin* contained in a fluid which gradually permeates the whole fruit; it further slowly accumulates as crystals on the outside of the cured pods. The pods are roughly divided into four classes according to size, and then, in batches of about four hundred, placed in a basket and plunged into hot water at about 190° F. for ten seconds. The process is repeated twice for slightly longer periods at intervals of half-a-minute, and, after the third dip, the pods are placed in boxes, lined with a blanket, to sweat; the pods themselves are also covered with a blanket to retain the heat. By the next morning the pods have assumed a chocolate-brown colour, and are then placed on shelves in drying rooms maintained at a temperature of about 110° F.; the slower the drying process the more perfect the curing. Well-cured pods should be much wrinkled, bending easily. When the curing is complete the pods are dried with pieces of flannel, and temporarily stored in boxes with tightly-fitting lids. They are then carefully sorted into different grades and finally bound up into bundles of about fifty each, and packed, with great care, for export.

The cultivation of vanilla affords a good instance of a planting industry threatened by the advances of modern chemistry. Within recent years considerable quantities of "vanillin," or artificial vanilla, have been manufactured on the Continent, chiefly in Germany and France. Vanillin was discovered as early as 1858, but its preparation upon a commercial scale did not meet with success until 1890, when the product was obtained from *eugenol*, the substance to which "oil of cloves" owes its characteristic odour. More recently vanillin has been prepared from sugar by an electrolypic process.

Pepper

Under the term "pepper" or "peppers" are included more than one spice, but the most important are the black and white pepper so largely used as a condiment. "Black pepper" consists of the dried, unripe fruits of *Piper nigrum*, a perennial climbing shrub found native in the forests of Travancore and Malabar in Southern India, and largely cultivated in Java, Sumatra, Borneo, the Philippines, Siam, and also in the West Indies.

A large proportion of the supplies come from the Malabar Coast. In planting pepper in this district, the jungle is cleared and planted with seeds of rice, cotton, castor oil, and other "catch" crops, and also with the seeds of *Erythrina indica*, the latter being a large tree subsequently used as a standard upon which the pepper vines are trained, and also as a shade tree. The catch crops are regularly harvested, but the Erythrina is left to grow for two years, when the poles are cut and planted out in regular rows. The pepper cuttings are then planted at the foot of the poles, which quickly take root and afford support and shade to the vines. Other trees used for a similar purpose are the Mango (*Mangifera indica*) and the Jak (*Artocarpus integrifolia*). In two or three years the pepper bears spikes of red berries which are carefully picked by hand, the men using light ladders to reach them. The berries are gathered before they are fully ripe, and after being separated from the stalk by rubbing with the hands or feet are spread on drying grounds (barbecues), where they become black and shrivelled. The product is then ready for the market.

"White pepper" has exactly the same origin as black pepper, but the berries are allowed to become nearly ripe. They are then soaked in water, and the outer skin of the fruits removed by rubbing with the hands.

"Long pepper" consists of the unripe fruiting spike of *Piper longum* dried in the sun. The plant is a native of the Malay Archipelago, but is also cultivated in many parts of India.

"Tailed peppers" or cubebs have been dealt with in the article on "Drugs."

"Cayenne Pepper": see "Chillies" in this article.

Cloves

Cloves are the unopened flower-buds of *Eugenia caryophyllata*, an evergreen tree reaching a height of twenty feet or more, and regarded by botanists as a native of the Moluccas. Supplies of the spice are chiefly obtained from Zanzibar and Pemba, but the best qualities are said to come from Penang and Amboyna. The clove is by far the most important agricultural product of Zanzibar and Pemba, where the trees flourish to perfection. They are raised from seed, the young seedlings being very carefully shaded and watered. When about six inches high the plants are gradually exposed to the full force of the sun and then planted out in regular rows at distances of about twenty-five feet. The clove tree begins to bear from the fifth to the seventh year. The picking of the young unopened flower-buds commences in August and lasts until about November, each tree being picked, on an average, three times a season. The stalks and buds are picked off by hand together, and thrown on to grass mats spread out on the ground. The curing process which follows is very simple; the cloves are picked from the stalks (which are subsequently used as a source of inferior qualities of clove oil), and spread out in the sun to dry, care being taken to place them under cover during the night to avoid the dews. The curing occupies about a week.



PEPPER VINES



CEYLON. DRYING CARDAMOMS

Zanzibar cloves are larger than the Pemba variety, and, unlike the latter, are not black but red in colour, being known in the trade as "Zanzibar red-heads." Cloves owe their valuable properties to the presence of a considerable quantity of the volatile oil, oil of cloves.

Nutmegs and Mace

This valuable spice consists of the dried kernels of the seeds of *Myristica fragrans*, a tree about twenty-five feet high, in general habit somewhat resembling an orange tree. The flowers are of separate sexes, the trees being either male or female: the nutmegs are, of course, obtained only from the latter. The round or oval fruits, which closely resemble a small peach in size and shape, are at first green, but become yellow on ripening. The thick, fleshy outer covering gradually becomes dry and leathery, and separates into two valves from the apex exposing the scarlet "mace," a reticulate membrane covering a thin brown skin which encloses the true kernel or nutmeg. The latter, when cut across, is found to be yellowish, with dark-brown mottled veins due to the infolding of the seed coat.

Myristica fragrans is a native of the Malay Archipelago, and is abundant in the Banda Islands, whence, for a long time, supplies were chiefly obtained. The industry, for many years, was a monopoly of the Dutch Government, but in addition to the plantations of Banda, Sumatra, and Java, numerous varieties are now cultivated in Penang, Singapore, Ceylon, and the West Indies, especially in Grenada. The plants are raised from seed, and nine years must elapse before the first crop can be gathered. It is only when they are six or seven years old that the female plants can be distinguished from the males, and of the latter only a few are allowed to remain for fertilisation purposes, the remainder being cut down to allow

of the planting of new seeds. Since this method is very uncertain and involves a great loss of time, the modern practice is to graft a branch of a female tree on to *all* plants when two years old before the sexes can be distinguished. When ripe, the fruits are gathered by hand and the outer part discarded. The mace is carefully removed to avoid breakage, flattened out, and dried in the sun, when it loses its brilliant scarlet colour. It is well known as a valuable spice. The seeds are dried in ovens or in the sun for several weeks until the kernels rattle in the thin outer seed coat. The latter is then broken and the kernels or nutmegs cleaned and packed for export.

The "mild" or "long" nutmeg is much inferior to the true nutmeg and is derived from a variety of *M. fragrans*, which is sometimes regarded as a distinct species, *M. fatua*. The Papua nutmeg is the kernel of *M. argentea*. There are several other so-called nutmegs which are of little or no use as a spice, the more important being the Calabash or Jamaica nutmeg (*Monodora Myristica*); the Brazilian nutmeg (*Cryptocarya moschata*); and the Californian nutmeg (*Torreya Myristica*).

Ginger

Ginger is prepared from the dried rhizomes of *Zingiber officinale*, a plant with a somewhat reed-like habit found truly wild only in Asia, but now cultivated in many parts of the tropics,



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CEYLON. PREPARING CINNAMON



A NUTMEG TREE IN JAMAICA

chiefly in South America, the West Indies, West Africa, and the warmer parts of Queensland. The finest qualities of the spice are probably obtained from China, and the West Indian product is also justly famous for its quality. The methods of cultivation and preparation are essentially the same in all parts of the world. In planting out, rhizomes of mature plants are cut up into short lengths, each possessing at least one "bud," which are planted about two feet apart. The harvest commences when the leaves begin to wither, which usually takes place after about ten months. The rhizomes are then very carefully dug up, and the fibrous roots and adherent earth removed. From this point the treatment varies according to whether dried or preserved ginger is required. Dried ginger is of two kinds, peeled and unpeeled, the latter being merely the cleaned rhizomes dried in the sun. In the preparation of the peeled variety, the cleaned rhizomes are thrown into water and then peeled with a narrow-bladed knife, care being taken to remove only the thinnest possible layer, since the essential oil and resin, to which ginger owes its pungent flavour, occur just beneath the skin or epidermis. After peeling, the ginger is again soaked in clean water to which chemicals are often added to improve the colour of the "roots." The ginger is then dried in the sun on a paved or cemented barbecue, the process occupying from six to eight days, when the product is ready for export.

Preserved ginger is prepared chiefly in China. The washed rhizomes are put into boiling water, and, after being peeled, placed in earthenware vessels and a strong boiling solution of sugar poured over them. The syrup is drained off after twenty-four hours, and the process repeated for two days. The ginger is then taken out of the syrup and is ready for export, appearing on the market either dry or packed in jars.

Allspice, Pimento

Pimento or allspice consists of the dried unripe fruits of *Pimenta officinalis*, a beautiful tree about thirty feet high with a straight trunk much branched above, bearing abundance of dense, evergreen foliage. The plant is a native of the West Indies, Mexico, and South America, but the chief supplies of the spice are obtained from Jamaica, whence the name "Jamaica pepper" is derived. The fruits are spherical berries, which when ripe are smooth, shining, and of a black or dark purple colour. They are gathered when of full size, but while still green. A boy climbs into the tree, and, bending down the branches, snaps off the smaller ends leaving the fruits which fall to the ground to be gathered by women and children. The berries are removed by hand, and carefully cured on large paved barbecues, the process occupying from six to ten days. The spice consist of small, spherical, wrinkled fruits about the size

of a pea, crowned with the remains of the calyx and style of the flowers. It possesses a very fragrant odour, and the name "Allspice" is derived from the fact that the object is regarded as resembling a combination of the fragrance of cinnamon, cloves, and nutmegs.

CINNAMON AND CASSIA

This spice is the bark of young shoots of *Cinnamomum zeylanicum*, a small evergreen tree indigenous to Ceylon and related to the camphor tree (*C. Camphora*). The plant is also said to be a native of the Malabar Coast, and has been introduced into Java, Réunion, the Cape Verde Islands, Brazil, the West Indies, and Uganda. Cinnamon was the most famous of the early exports of Ceylon, and, until 1833, was a Government monopoly. With the abolition of the monopoly the cultivation greatly increased, especially in the light, sandy soils near the south-east coasts. At the present day about 40,000 acres are under cinnamon in Ceylon.

Left to itself, *Cinnamomum zeylanicum* would be a small tree, but in the plantations it is kept coppiced in order to induce the formation of long willowy shoots from which the bark may be obtained. The shoots are cut and trimmed with a knife, the small waste pieces resulting from the operation being known in the trade as "cinnamon chips." The bark is then slit longitudinally and removed in strips with a special knife. The strips are collected into bundles, which are piled in heaps to undergo a slight fermentation, a process which facilitates the next operation of removing the epidermis by scraping with a curved knife. The bark dries and contracts into the well-known "quills," which are bound into bundles. Cinnamon peelers are a separate caste among the Sinhalese.



NUTMEGS

The finest qualities of cinnamon are light yellowish-brown in colour, smooth, very thin, and, to a certain extent, pliable. Inferior grades are darker and thicker, with inferior fragrance. As is the case in most spices, the fragrance is due to the presence in the bark of a volatile oil ("oil of cinnamon"); similar but inferior oils are obtained by distillation of

the leaves and roots. "Cassia" of the ancients was probably derived from the bark of several species of Cinnamomum, but the cassia of modern commerce ("Chinese Cassia") is the fragrant bark of *C. Cassia* (*C. aromaticum*), a plant growing abundantly in southern China, whence there is a large export. The bark is often used to adulterate true cinnamon. Saigon Cassia is regarded as superior to Chinese Cassia; it is grown in French Indo-China.

Cardamoms

This spice, better known in India and the East than in Europe, consists of the seeds of two species of Elettaria, viz., *E. Cardamomum*, the Malabar cardamom, found in the moist forests of north Canara, Coorg, and Wynaad; and *E. major*, the Ceylon cardamom, a variety of the first species. The plants have a reed-like habit and bear long, loose racemes of flowers succeeded by triangular capsules containing the seeds.

The fruits, which vary from half-an-inch to two inches in length, are collected from wild plants and also from plantations, the latter being generally laid out in partially cleared forests in which the wild plants are known to occur. When about three years old the plants begin to bear. The capsules do not all ripen at the same time, and the harvest lasts for nearly three months. The capsules are gathered before they are ripe and then cured in the sun, after which the stalks and remains of the flowers are carefully removed by means of scissors. Cardamoms are exported in the capsules in order to prevent adulteration of the seeds. The seeds are small and irregularly angular, possessing a very delicate aroma. They were well known to the ancients, and are very largely used throughout the East as a condiment. They are employed to a small extent in Europe for flavouring sweetmeats. At the present time great interest is being taken in cardamom cultivation in Ceylon, and special efforts are being made to push the sale of the product in the markets of Australia and Europe.

Several other varieties of Cardamom enter into the commerce of the East, but they are all inferior to those described above.

Chillies and Cayenne Pepper

Chillies are the dried fruits of *Capsicum minimum* and *C. frutescens*, small erect shrubs with spreading branches. The former is the more important, and, although a native of India it is now found in all parts of the tropics, being largely cultivated in East and Central Africa and in South America. The pointed, oblong fruits are about three-quarters of an inch in length, and of a bright scarlet colour, changing to orange-red on drying. They are used for pickling and, when ground in a mill form "cayenne pepper." The pungent principle of the condiment exists chiefly in the partition dividing the fruit into two chambers.

Mustard

This popular condiment should consist, properly speaking, of the flour obtained by grinding the seeds of *Brassica nigra* (Black Mustard) and *B. alba* (White Mustard), plants belonging to the Crucifer family, and widely distributed in Europe and certain districts of North Africa and Asia. Much adulteration is practised, however, with starch, turmeric, and other substances. The plants mentioned are largely cultivated in several parts of the Continent, and in the eastern counties of England. The finest mustard is obtained from the small reddish-brown seeds of *B. nigra*, the larger yellow seeds of *B. alba* yielding inferior qualities. When ripe the seeds are threshed from the plants, ground between rollers and pounded, the resulting flour being sifted into various grades.

Brassica juncea, largely cultivated in India, is the source of "Indian" or "Brown" mustard.

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